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## HEDGE CUTTING MACHINE.

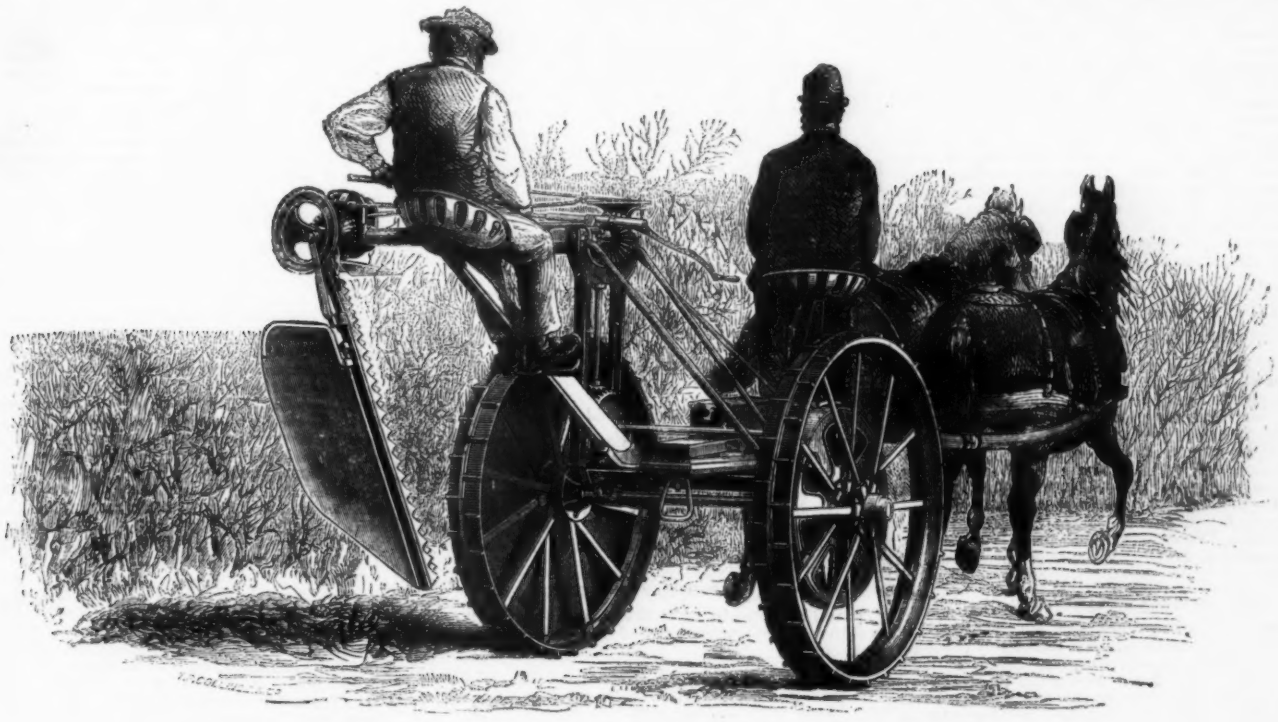
AMONG the latest applications of mechanical power for superseding hand labor, must be reckoned the hedge cutting and trimming machine, introduced at the last Royal Show by Messrs. R. Hornsby & Sons, of Grantham.

It is mounted on two traveling wheels, between which are fixed the seats for the driver and machineman, and the gearing for communicating motion to the cutting apparatus. From one side of the main frame rises a standard, carrying a tubular arm, capable of being extended by the action of a lever, the handle of which comes conveniently near to the man who manages the machine. From the end of this arm hangs the cutting apparatus, which consists of one fixed and one reciprocating knife, each composed of a number of "sections," such as are used on mowing and reaping machines, but larger and stronger, in proportion to the heavier work required of them.

The bar carrying these two knives is loosely pivoted to the end of the extensible arm, so that it may be set at any angle of inclination, a worm and wheel with spindle running along the arm, and terminating in a handle, also within reach of the man, provides for the adjustment to the required angle, so that from his seat he can vary at will the "slope" of the hedge, and also withdraw the cutters instantly to pass a tree, gate, or other interruption to the cutting. The height of the bar, and, consequently, of the cutting gear, is regulated by a wheel and pinion acting upon a screwed stay passing from the axle of the main wheel to the center of the arm.

This stay does not appear in our illustration, as the man obstructs the view, but its position will be readily understood. The operation of the machine is very simple. The projecting arm is raised to the height of the hedge about to be cut, the correct inclination is given to the cutting apparatus, and the machine is ready for a start. The driver has only to keep his horses at a steady pace, and at an equal distance from the hedge, the management of the machine being entirely left to the man occupying the back seat. This man grasps the lever connected with the extensible arm, and by it guides the cutters, pressing them outwards, if the horses incline from the hedge, or drawing them inwards, if they go closer to it. He is thus able to preserve a regular cut, in spite of any slight deviation of the horses. By the same lever he can also completely withdraw the cutters from work to pass a tree or any other obstruction. In this way the side of the hedge next the machine is cut, and, when circumstances are favorable, each field would be so cut all round.

When, however, the adjoining field is either in a different occupation, or has a ditch which prevents the machine traveling in it, the cutting bar (which, as already explained, is hinged to the arm, on the principle of Messrs. Hornsby's "Paragon" mower, so as to cut freely at any angle) is passed over the hedge, the angle of inclination being reversed, and so the other side may be cut. If, after this, it is desired to "top" the hedge, the cutter can be extended in a straight line from the machine, and so take off the A-shaped point which was produced by the two former cuts. In most cases, however, the "topping" will not be considered necessary, as the appearance of a hedge after both sides have been cut is all that can be desired.—*Iron.*



ENGLISH HEDGE CUTTING MACHINE.

## GRASS CULTURE.

GRASS is king among the crops of the earth. It lies at the very foundation of all our agricultural prosperity and success, for more land is devoted to its cultivation, and more money realized from it than from any other product. Mankind for ages lived without utilizing cotton, but never existed without being benefited by the grasses and grains. Eden would never have been a paradise had not its fields been covered with the velvet carpet of green grass. The statistics of the nations of the earth prove that grass is the most essential and most remunerative of all crops. Grass is an indigenous product of our soil, as it springs up spontaneously on all soils, while most other useful crops must be sown. As soon as the forests are cleared and the sunlight let in upon the ground, we find the nutritious grasses clothing the earth with verdure most pleasing to the eye of man, and furnishing all herbivorous animals with life-sustaining food. Chemical analysis and careful experiments agree in assigning a higher nutritive value to well made hay, in comparison with grain and roots, than is generally allowed. From referring to several tables of nutritive equivalents, we find that 100 pounds of good English hay is equivalent in nutrition to about one bushel of corn or barley, two bushels of oats, four bushels of potatoes, or five bushels of carrots. And as we can raise 100 pounds of hay at less cost than a bushel of corn or four of potatoes, it follows that hay should be the leading crop, where crops are grown expressly to be fed to stock.

### FACTS AND FIGURES.

Among the official returns for 1875 of the products of Massachusetts, we find that the value of the leading staple crops is as follows, viz.:

| | | |
|---|---|---|
| Hay crop | | $10,660,270 |
| **GRAINS.** | | |
| Corn | $1,114,554 | |
| Barley | 47,655 | |
| Oats | 314,202 | |
| Rye | 248,437 | |
| Wheat | 23,105 | |
| Buckwheat | 46,911 | |
| Total | | $1,794,864 |
| **VEGETABLES.** | | |
| Potatoes | $2,349,815 | |
| Beets | 116,091 | |
| Carrots | 86,503 | |
| Turnips | 252,222 | |
| Total | | $2,804,631 |
| **DAIRY AND MEAT.** | | |
| Milk | $5,934,671 | |
| Butter | 2,747,878 | |
| Cheese | 168,826 | |
| Beef | 12,248,542 | |
| Mutton | 55,374 | |
| Total | | $21,135,291 |

Thus we see that the value of the hay crop is more than twice that of the combined values of all the grains and vegetables, as the hay crop in value amounts to over ten millions and a half dollars, while that of the combined values of grains and vegetables is less than five millions. We also find that the combined value of the dairy, beef and mutton amounts to over twenty-one million dollars, and this is principally produced from our grass crop, and should we add to this the value of the live stock fed chiefly from the grass of our fields, and the value of the manure from this stock (over two million dollars), we should be almost astonished at the magnitude of the figures. We have shown that the grass crop of Massachusetts exceeds in value all the other agricultural products combined.

### THE HISTORY OF GRASS CULTURE.

We find little attention paid to the cultivation of grasses previous to the 17th century. Clover, as a cultivated plant, was not introduced into England till about 1640, and the white Dutch clover till 1700. We learn that in 1680, in England, was the beginning of systematic culture by the introduction of the perennial rye grass, and for many years this and clover alone were the only varieties cultivated, and not until the introduction of herdsgrass and orchard grass from this country, did grass culture take a grand start in agriculture. In our own country, the culture properly began by the disseminating of the seed in 1760 of timothy, herdsgrass (now known by either name), by an English farmer in Pennsylvania; and in 1764 by the introduction of orchard grass in Virginia. Even the knowledge of the different varieties of grasses was then so meager that the farmers in the colonial times would feed down all the ripening grasses so that kind nature could not replenish the barren fields by self-sowings; but as the grand science of agriculture began to be developed, we find the finer and more nutritious varieties began to be cultivated.

### CULTURE.

The importance of the hay crop is such as to demand the most judicious and intelligent culture. In preparing the soil for seeding down to grass, the land is generally in one of these conditions, viz., sod land, summer fallowed, and old cultivated soil. If the conditions of the soil are favorable to the growth of such small seeds, we consider the first method preferable. If the grass roots are too feeble for topdressing for another crop, then turn over the sod about five inches deep in July or August, with a good swivel plow; then put on the Randall or La Dow harrow, and thoroughly pulverize the soil; then apply a liberal dressing of stable manure, or a heavy dressing of special fertilizer for grass, such as nitrate of soda with bone dust, etc., harrow this in well, and leave the surface fine, light, and level, and our field is ready for the seed. We recommend summer fallowing only when the land is filled with couch grass—*Triticum repens*—or other obnoxious plants.

### SOWING THE SEED

is a very important part in the successful culture of grass, for we must study to know the nature of the soil of our different fields; also, the adaptation of the varieties of grasses to the soils best suited to their growth. At the very outset, we say that our farmers must sow those varieties of grasses that blossom at the same time, *i. e.*, the early grasses by themselves, and the late by themselves; also to sow a greater variety together, and a larger quantity of seed to the acre, than are generally sown, for "he that soweth bountifully

shall also reap bountifully." We recommend the following formula for hay seed to the acre:—

| *Early Varieties.* | | *Late Varieties.* | |
|---|---|---|---|
| Red clover ..... | 10 lb. | Herdsgrass..... | ½ bush. |
| Alsike " ..... | 5 " | R. I. bent grass... | ⅔ " |
| Orchard grass..... | 1 bush. | Eng. redtop..... | 1 " |
| June " .. | 1 " | | |
| Perennial rye .... | 1 " | | |

In sowing down to permanent pastures, a variety of grasses which will ripen in succession is desirable, for we have varieties that are maturing in succession for nearly five months of the year. In late April we have the old spear grass in blossom; in May, the white clover, sweet vernal and fox tail; in June, a legion of varieties, the principal ones are June grass, orchard fescues, rye grass, red clover, and others; in July, herdsgrass, bent grass, and red top; in August, fowl meadow, blue joint and meadow foxtail. It is well known that any variety of grass will continue to grow if cut or fed off before it goes to seed, as the production of seed is the great end aimed at in nature.

WHEN TO CUT GRASS,

has been a mooted question among our best farmers, but careful experiments have clearly proved that to secure the hay crop in its very best condition, all varieties should be cut just as the blossom buds are breaking, and before the pollen falls, *i. e.*, all the clovers when the heads are about half in bloom, and the other varieties as soon as they come into full height. All grasses pass rapidly from the blossom stage to that of maturing the seed, and they must be cut just in time to secure the largest amount of food, and in the best condition to feed; and this we can do when the grass has attained its growth, and before the starch, sugar, and gluten of the plant have been converted into woody fiber, or the formation of seed; it should be remembered that the nutritious compounds increase so long as the plant grows, but when it blossoms, growth stops, and then is the time to secure the greatest amount of forage in the best condition. To do this we have every facility in the way of labor saving machinery, to assist the farmer; and with good bright weather, the laborious part of haying has been converted into almost a pleasure.

The best and most practical method of securing the hay crop we have found is to put the mowing machine at work about 4 P.M., and cut till about sundown, or till the dew falls; then, as soon as the dew is off the next morning, put the hay tedder into the grass and keep it turning till dry enough to house, then have the wheel horse rake gather into large rows or tumbles, to pitch into wagons, and put into the barn as rapidly as possible, and pack down tight. When all is drawn off, go over the entire field with the horse rake and glean every straw clean. With clover we prefer to cut and give it all the sun and air possible the first day, then put into snug, good sized tumbles, and cover with hay caps for a day or two, then air and put into the barn, packing it very closely by treading it hard and heavy. As soon as the crop is off, apply some good fertilizer or compost; bush over and roll down the stubble smooth. This protects the roots and gives a good start for the next crop. Early in October a good coat of coarse stable manure should be spread evenly over the field. This not only stimulates the roots for another year, but makes a good protection for winter.—*A. F. Stevens, in N. E. Farmer.*

## THE CASTOR BEAN PLANT.

By HON. EDWARD BALLAINE.

Two varieties are cultivated in Southern Kansas: *Ricinus communis* and *Ricinus sanguineus*. The first is the little Illinois bean, and is cultivated as a commercial article. Stalks purple, leaves bluish-green, spikes green, and grows in this latitude, in upland, eight to ten feet high, and from one and a half to three inches in diameter at base. The second is the ornamental bean, so-called—red stalks, large scarlet spikes, and leaves purple; grows like a tree. Children can climb in the branches six or eight feet from the ground. Height, twelve to fifteen feet, and from four to five inches in diameter at base. The spikes of this variety do not yield their fruit by action of the sun; hence it is only grown for ornament here.

THE CASTOR BEAN PLANT.—R. C.

The seed leaf is like every other bean, but the young leaf is pushed up by its own stem, which it completely envelops, and when unfolded measures three or four inches in diameter, and resembles a half-globe. When the plant is about eighteen inches high, the first or center spike shows itself. The plant then divides into two branches, growing a foot or so, when again at the end of these is the second set of spikes. Each branch again divides and grows, bearing the third set of spikes. These again invariably divide, bearing the fourth set, and sometimes the fifth set is formed on a similar division; but these latter did not mature here. Besides, if a plant has plenty of room, lateral branches will grow from every leaf-bud below the first fork, which will bear one or two sets of spikes each. I have counted thirty-three spikes growing on one plant. In July the leaves measure from eighteen to twenty-seven inches in diameter (with a stem from fifteen to twenty-four inches long, almost in the center of the leaf), and look like open and gracefully-held parasols. When the first spikes are cut, in a few days all the leaves below them die and fall; the second set the same, and so on, until all the spikes are cut. And the plant, which was a magnificent sight in July and August, becomes in October, when disrobed, an unsightly bush.

The spikes carry fruit and fertilizing buds; the former, a deep green pod-shaped, with scarlet silks just peeping out; the latter, yellowish and pea-shaped, which in a few days open and emit a yellowish dust. Some spikes are nearly all fruit-buds; others, nearly all fertilizers: but generally every spike has a few fertilizers at its base, the remainder being fruit-buds. The first or center spike is always the largest, growing from twenty to even thirty six inches in length, and diminishing in a regular ratio. Where a center spike measures twenty-four inches, the fourth set in the same tree will measure six and one-half inches. Over five hundred boils have been counted on one spike. The bolls are roundish, about three-fourths of an inch across, and contain three beans each, sometimes four. We have found bolls with six, seven, and eight beans; but these are rare.

CULTIVATION.

Castor beans do well in the gray soil of our valleys. They will not grow so tall, but I think will produce more than on limestone land. Our beans grew on this latter soil, on ground broken five years, and had produced successively wheat, corn, oats, and wheat, after which beans were planted. We plowed the ground in winter, with three horses, from eight to ten inches deep; we marked as for corn, four feet apart. When the ground commenced to be weedy, we opened furrows with a shovel plow, crossways, about four feet apart. We dropped the beans by hand in these furrows, two in a hill, and covered lightly with the foot. Planted first of April. In every seventh row we planted white beans, so as to leave an open space for the wagon. Plowed or cultivated four times, the last plowing being about the first of July, the beans then being three and four feet high.

HARVESTING.

The spike is ripe as soon as one or more bolls on it have turned brown or opened, and not before—the center spike ripening first, then the second set, and so on. By experience the picker soon tells them, both by the color of the spike and the touch. The former is of a darker green, and somewhat glazed. When growing, the bolls are covered with a hairy coating, which is soft to the touch; but when the spike is ripe this turns stiff and bristly, indicating that the spike, having ceased to absorb from the parent plant, is now drying up, and, of course, ripe. Amateurs should never cut a spike until some of the bolls have expelled their fruit. We drove a wagon and team in the blank rows, cutting three rows on each side of the wagon. We gathered, after the first picking, two loads to the hand per day. A load of spikes well tramped were equal to twenty-two bushels of corn in the ear, and yielded five and one-half or six bushels of shelled beans. We picked five times—first, commencing 15th of August; second, 1st of September, and every eight or ten days thereafter, until the last were gathered, which ended the 6th of November. They ought to have been picked once more, but we were unable to do so on account of sickness.

POPPING THE BEAN.

Here, the beans are popped on the ground. I tried a building with several floors, through which were open spaces for the shelled beans to pass—a very nice plan, but too slow. After trying many ways to prepare plans, I found the following the quickest and the best: we hauled old hay and flax straw, to the depth of a foot or more, on prairie sod —*i. e.*, unbroken ground—and burnt the same. Burning against the wind, it burnt the heart of the grass and tufts deep, and left a smooth, unbroken surface, which needed only sweeping to be ready. Twenty by twenty feet or more of floor are necessary for every acre of beans. The beans are unloaded with a pitchfork, in piles of a wagon-load. The next day they are spread, and ought to be only one spike thick. It takes them five or six days in dry weather to open. When sufficiently dry, we helped them by rolling with a two-horse roller, drawn by unshod horses, without hurting the bean. They are expelled, in opening, to the distance of a few feet. The stems of the spikes are then raked; the beans and hulls are scraped and swept together; after which they are fanned, using a coarse screen to separate the ground and dirt. The bolls which are not open are again exposed to the sun, and the floor is again ready for a like process.

YIELD PER ACRE.

The first picking we gathered thirteen loads, nearly all of which we lost, they having been gathered too green and spread too thick on the floor.

| | | | | | |
|---|---|---|---|---|---|
| First picking..... | Saved | 20 | bushels of | 46 | pounds. |
| Second " ..... | " | 79 | " | 46 | " |
| Third " ..... | " | 84 | " | 46 | " |
| Fourth " ..... | " | 90 | " | 46 | " |
| Fifth " ..... | " | 55 | " | 46 | " |
| Total saved..... | | | | | 328 bushels. |
| Average price at which sold..... | | | | | $1.07 |

There were thirty acres, less one-seventh blank rows, and two acres washed away by rains, leaving twenty-three and one-half acres of beans, and yielding about fourteen bushels to the acre; and not only in our fields, but it is safe to say that throughout the county wherever castor beans grow, there are now, on every square foot of ground, from eight to ten beans, and in many places four times that quantity, that popped in the field.

EXPENSE OF GATHERING.

It will be borne in mind that this was nearly all done by children under sixteen years of age, and but little money paid out.

| | | | |
|---|---|---|---|
| First picking ..... | 3 hands..... | 3 days. | |
| Second " ..... | 3 " ..... | 5 " | |
| Third " ..... | 3 " ..... | 5 " | |
| Fourth " ..... | 3 " ..... | 6 " | |
| Fifth " ..... | 3 " ..... | 6 " | |
| Total ..... | | 25 days. | |

Three hands twenty-five days equals seventy-five days; at forty cents per day, equals $30.

Also, one hand, at $15 per month, making floor, tending same, marketing, etc., for two and one-half months, $37.50.

It will also be noted that this was an experimental crop, without having or being able to obtain much information concerning the said crop. With the experience acquired this year, I do not hesitate to say that a product of twenty bushels per acre, on an average, will be a low estimate for future crops.

REMARKS.

It is not necessary to leave a blank row, as the wagon does not break the plant; but always go the same way over the bent row. Two quarts of seed are sufficient to plant an acre. Great care should be taken in selecting seed from the same picking, and even from the same set of spikes. Our seed, and that of others, was purchased of merchants from a miscellaneous lot of beans. They came up, grew, and ripened very unevenly. They should always be thinned to one in a hill. On gray soil, four by four feet may do, but on limestone land five by five would be much better. A bushel of prime beans yields, with a hydraulic press, two gallons and three pints of oil; with a screw press, about two gallons. The oil is used for medicinal and lubricating purposes, and there is a very marked increase in the demand, especially for the latter, this year. Until the year 1874, twenty-five per cent. of the beans used in this country were imported from India. None are imported now. The manufacturers claim that the products of the castor bean cannot be exported until they can buy beans at St. Louis for fifty cents a bushel. St. Louis is the center of the manufacture of castor oil. Our children, while planting, ate a few beans, after peeling the hull, causing nauseous sensations. Some of them ate a dozen. Our horses have not suffered at all from plowing and gathering the crop. Care, however, has been taken never to feed in a wagon box containing shelled beans. The grasshoppers will not touch the plants and chinchbugs will not even cross a field containing them, the heavy rains do not injure them, and they mature well in seasons of drought.—*Kansas Agricultural Report.*

## CLEANSING TREES WITH SOAP.

A CARPENTER who worked for me some five years ago first called my attention to the effects of soft soap when applied to the bark of young apple trees. He had a young orchard to which he paid considerable attention. One of his trees was smaller than the rest; looked badly and was full of ants. He supposed (though no doubt erroneously) that the ants were injuring the tree, and determined either to clear them out, or kill the tree, with soft soap. He put it all over the tree, on the body, limbs, and even on the young growth. In a short time the leaves dropped off, and he thought he had killed it sure enough. But to his surprise it entirely recovered, put on new growth, and grew more vigorously than it ever had before. In a few years it had outstripped every other tree in the orchard. He had since been applying soap regularly to all his trees, and finds them all benefited by it.

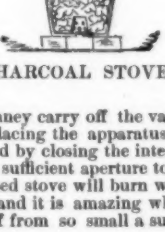
My own experience is of four years' duration, with an orchard of 75 trees. They are fifteen years old, and average about fifteen feet high and six inches through the body. I can safely say that they have a more healthy appearance than they had before the soap was applied (they have been scraped with each soaping), and they have passed through two of the most severe winters without the slightest perceptible injury. All the fruit they have borne has been the finest of its kind. For the past two years the Harrison apple trees have not borne so much as they did before, owing, I think, to the extreme rapidity of their growth, but they will be all the better for it afterwards. By examination, I find the bark on some of the fifteen year old trees is nearly as smooth and thin as on the five year olds—all having been cleaned every summer for three years.

This brings up the point about trees absorbing nourishment through the bark. Nelson Ritter says that "probably old trees receive no nourishment through the bark, but this has never been proved." Has it ever been clearly shown that young trees receive nourishment through the bark? The above instance of the carpenter's tree making such a rapid growth after the soap was applied would seem to point to this conclusion; but this was only a single instance, and might admit of a different interpretation. If it has been unmistakably proved that young trees receive fertilizing matters through the bark, then, I ask, would not the trees continue to do this farther into old age, by keeping the bark clean and thin, instead of neglecting the bark till it becomes thick and protects the trees when they need no protection? The only time that trees ever need protection from winter, in this climate, is during the first few years of their growth, and the bark of a young tree is always thin. How absurd, then, to leave the old rubbish on the older trees for protection, when it only accumulates after the tree is out of danger!

Last year I noted the time it took to soap my trees. A man and a boy went over the orchard between one o'clock and five in the afternoon—say 7½ hours for one man to do 75 trees, or one hour to do ten trees. Counting ten cents an hour as the wages of a man, we have one cent a tree as the cost of the labor. On the 75 trees there was applied about three gallons of strong soft soap, or about a third of a pint to a tree, mixed with an equal quantity of water. Call it half a pint to the tree, and put it at two cents, and we have three cents a year as the entire cost of soaping a good large apple tree. If the soap is put on regularly, the trees need not be scraped oftener than once in two years. All who own apple trees may not be experts at making soap, or may not have a sufficient quantity ready made. In either case I would neither make it nor buy it, but use the ordinary potash lye from wood ashes. Dilute it to the proper strength with water. Lye that will just not take the skin off the hand is not too strong for trees.—*Augustus Stabler, in the Country Gentleman.*

## A CHEAP CHARCOAL STOVE.

I SAW the other day, at a friend's house, one of the simplest and most effective stoves for a small conservatory it is possible to imagine. It was composed of three 12-inch ordinary flower pots. The hole at the bottom of the lowest was covered with a small pot, into the sides of which had been bored a number of holes. The pot was then three parts filled with charcoal, and lighted from the top. This is the furnace. It is covered by pots Nos. 2 and 3, and a light



CHARCOAL STOVE.

tin funnel and chimney carry off the vapor. The draught is maintained by placing the apparatus upon a couple of bricks, and regulated by closing the intervening space with mud, leaving only a sufficient aperture to keep the fire burning. This improvised stove will burn without attention for twenty-four hours, and it is amazing what a great amount of heat is given off from so small a surface.—*S. J., in the Gardener's Chronicle.*

## THE CHARLESTON PHOSPHATES.

So much has been written and said regarding the remarkable deposit of phosphatic rocks on the Ashley River, near Charleston, S. C., that the locality has become famous throughout the civilized world. In a visit to the deposits, last winter, we learned many interesting facts regarding their nature, extent, and working, some of which we will present to our readers. The rocks are of various sizes, from

that of a hickory nut to a peck measure, and although most of them are embedded in a tenacious clay or marl, at various distances from the surface, rarely exceeding ten feet, a considerable quantity lie loosely above ground, and until their true nature was discovered, a dozen years ago, were regarded as a great disadvantage to the land by the owners. They were detested by the farmers, like our northern drift rocks, which interfere with easy cultivation. These rocks extend over an immense area—hundreds of thousands of acres—and practically the supply may be said to be inexhaustible.

Geologically speaking, the region is in every respect remarkable. It is a vast basin, covered with mud and silt, and formerly open to the inflow of the tide. In this region are found the most wonderful remains of ancient and extinct species of animals. There are whole acres richly studded with fossils. Among these have been recognized the bones of the mammoth, mastodon, megatherium, mylodon, megalonyx, phocodon, several varieties of the sauri; also teeth and bones of the shark and numerous other fishes in great variety; with teeth and bones of the horse, dog, sheep, ox, and hog, differing but little, if at all, from those belonging to our present domestic animals. Pieces of pottery, too, have been found, together with stone hatchets, all in this same bed, almost identical in their character with similar remains found some years since near Abbeville, in France. There have also been found one or two human bones, though the evidence on this point is still somewhat defective.

This strange collection, this miniature sepulcher of the ages, where animals extinct sleep side by side with others, the ancestors, perhaps, of our daily companions; where men, beasts, reptiles, and fishes would seem to have found a common grave—these fossils occur in the postpliocene strata. They have been described in the scientific journals by Professor F. S. Holmes, who has devoted many years to their study.

In a heap of the rocks, representing, perhaps, a couple of cords, we found fragments of deer's horns, perfect sharks' teeth, and numerous other fossils of more or less interest. In answer to the question, What is the history of this great sea-basin? we have little to say, as nothing is positively known regarding it. All rests upon conjecture, and of the hypotheses which have been presented some are so preposterous as to be unworthy of mention. That vast numbers of marine and land animals have in past ages been here entombed does not admit of a doubt. The evidence upon this point is conclusive. It may have been for some reason very enticing foraging ground for the two classes of animal life, and here they found common graves. It could not have been by any sudden entombment, as it is not probable that such immense numbers could have been congregated at any one time. The burials must have extended over great epochs, and those very far in the past.

How were these strange rock nodules formed? How came they here? It is indeed very tantalizing that we have no positive light upon these interesting questions, but there is none, and we will not take up space in this paper in the presentation of any speculations upon the subject. It having been shown that a knowledge of the existence of the rocks must extend back to the time of the first settlements upon the coast, it now remains to inquire, When was the discovery of their *chemical* nature first made? And here we may remark that it is curious that these rocks, and the extraordinary basin in which they are found, had been repeatedly examined by scientific men during at least half a century, before analysis revealed their nature, and yet no one suspected their true chemical constitution. These persons seem to have been more intent upon finding sharks' teeth of monstrous size, and other fossil specimens, than upon making chemical investigations of the rocks among which they occur. It is conceded that Dr. N. A. Pratt, of Charleston, was the first to discover the phosphatic nature of the rocks. He conceived the idea, in 1866, of establishing works for the manufacture of acids and fertilizers in Charleston, and this led him to look about for a supply of materials. In his statement of the investigations made he remarks as follows:

Recalling to my mind the "Fish Beds" of the Ashley River, and the "nodules" or "conglomerates" buried there, I applied to my friend, Professor F. S. Holmes (who, among all my acquaintances, was best informed as to the geology of this section of the country) for samples of those and similar rocks, and finding in his cabinet a quantity taken twelve years before from his own plantation on Ashley River, was pleased to discover on August 10, 1867, No. 1 phosphate of lime, 55.92 per cent.; No. 2, phosphate of lime, 55·52 per cent. Subsequent analyses, made in the next few days, of the rocks taken by myself from the bed showed averages varying from fifty-seven to sixty-seven per cent., which could be relied on from a very large extent of country; thus I have found these phosphates to be identical with the "marl stones," "nodules," or "conglomerates" of the "Fish Bed of the Charleston Basin," all the physical characters of which had been known and described twenty years before; and the nodules, of which I was informed by Professor Holmes, were known to contain fifteen or sixteen per cent. of phosphate of lime. Availing myself of Professor Holmes' extended information in regard to the outlines of the bed, which he had many years ago mapped out, I pushed forward my examinations and explorations with flattering results, and in a few weeks extended the limits of the bed far beyond its previously known boundaries. Thus this valuable material was discovered and located.

As might be expected, the discovery soon created great excitement, and companies were speedily formed for purchasing and working the beds on a large scale. The owners of almost worthless marshy lands awoke suddenly to find them sought for at very high prices, and many, of course, became unexpectedly rich. The rocks yielding the highest percentage of bone phosphate were found in the bed of the Ashley River and adjacent lands, about a dozen miles from Charleston, and here extensive excavations have been made. In three years from the time of the discovery fourteen companies had been formed, representing several million dollars of capital, for the purpose of raising the rocks and manufacturing fertilizers.

We visited some of these establishments, and witnessed the process of manipulation. Several of them are but a few miles from Charleston, and the works are of great extent, including chambers for the production of sulphuric acid. The commerce of the port has been immensely increased by this new industry. Vessels are continually arriving with cargoes of sulphur, guano, fish pomace, etc., and many are departing loaded with the rock and manufactured phosphates. England has thus far been the largest consumer, and English manufacturers have houses established in Charleston devoted to the interests of the trade. The value of the fertilizers shipped in 1870, three years after the discovery, was upwards of two millions of dollars. It is stated that the yearly production at the present time is about 200,000 tons, two thirds of which is exported to England, and only one third consumed at home. At the present time great complaint is made of dull trade and low prices, and a feeling of discouragement prevails. We are of the opinion that this state of things is not solely the result of hard times, but is partly due to the poor quality of the products. The manufacturers have learned, and the planters have learned, that imperfectly made phosphate alone will not grow cotton or the cereals; something more is needed. An important factor in this "something" is nitrogen, which the rocks do not supply. Attempts are made in some of the establishments to meet this want by adding to the rock powder a quantity of fish refuse, or "fish pomace," as it is often called. This supplies a trifling amount of nitrogen, and gives to the mixture that intolerable odor, thought to be so requisite in a *good* fertilizer by the planters. In the early spring, when the fertilizers are passing over the various railroads, traveling in the South is disagreeable, as the whole atmosphere is pervaded with the odor of rotten fish. Without some agent of this kind the fertilizers would be almost odorless. So far as our observations extended, we formed the opinion that the machinery used does not grind the rock fine enough to make available the phosphoric acid when it is acted upon by vitriol. The fertilizers were of low grade, containing not more than two per cent. of nitrogen, and six or eight per cent. of soluble phosphoric acid.

In the use of such agents farmers and planters are disappointed, and hence the demand is falling off from year to year. In Georgia, and we believe in several of the Southern States, the law requires that the analyses of fertilizing agents be placed upon the packages which contain them, and this is done by the manufacturers. If these analyses are correct as given, they show inferior products. We noticed this, and called the attention of mill superintendents to the fact, but the reply was that they were acting under the direction of owners, and assumed no responsibility. It is poor policy for the phosphate workers to throw poor products upon the market.

As regards the future of the Carolina phosphate industry, it is difficult to predict. Long-continued pecuniary success depends upon circumstances. Honest fertilizers will always, in our view, bring large amounts of honest money to the pockets of manufacturers; bad agents will not in the end sell at any price. Spain is likely to become a dangerous competitor for the supply of mineral phosphates. Very rich and extensive mines have been opened at Logrosan and Caceres in Spain, and this circumstance may influence the products at Charleston. No other country in the world but Spain has deposits at all comparable with those of Charleston. The Spanish phosphorite gives in the manufactured superphosphate from 10 to 20 per cent. soluble phosphoric acid; the Charleston gives from 10 to 15½. The Spanish is the richest product yet discovered. The advantages of location and availability of transportation are altogether with our deposits, and it must be a considerable time before the active trade can be diverted to other channels.—*Boston Journal of Chemistry.*

## TESTS FOR BUTTER BY LIGHT.

A WRITER in the *Hannoversche Monatsschrift* is even more sanguine than Mylius, who first proposed the examination of butter by polarized light, of the value of his method of testing the purity of butter. Under such light the peculiar crystals come out very distinctly. He has discovered that different fats, like the minerals, produce characteristic marks whereby they can be determined in the polarization colors, and he intends soon to publish plates showing the peculiar forms and colors of each fat, whether raw or melted, or crystallized from glycerine. Mutton tallow gives a blue tone; ox fat, green and white; hog's lard, red and blue, with other colors not so intense; cacao butter, a play of color from the deepest red to the brightest green. Besides being useful as tests of the genuine nature of butter, these optical reactions are said to be available for the detection of foreign fats that may be fraudulently added to chocolate or cocoa.

[Translated from *La Correspondance Scientifique.*]

## THE BEGINNING AND END OF THE WORLDS.

By CAMILLE FLAMMARION.

THE question as to the beginning and end of the world, has justly excited all minds that love to explore the mysteries of nature; and the progress of contemporary science permits us to-day to answer it, and to write, not a universal history of one people and one doctrine, with a duration of six thousand years, as Bossuet did, but that of the entire planet, with a duration proportionate to the grandeur of the universe.

### I.—THE BEGINNING.

As we did not assist at the creation of the world, we can only form an idea of the events which took place by employing in our researches the only method that is serious and fecund—that of scientific induction.

Now we see that the enormous globe of the sun hovers in the center of his system, turning on his axis in twenty-five days and a half, and that all the planets revolve in the same direction around him, almost in the same plane. We see also that the density of the planets is so much the less in proportion as they are more distant from the sun. We remark at the same time that the materials that compose them are of the same nature as those that compose the earth and the sun. Here, then, is a great family whose unity of origin is evident.

The form of the terrestrial globe, moreover, shows that it commenced in a fluid state, and it is the same with all the other planets. In spite of some difficulties of detail, the only cosmogonic theory admissible is that which represents the planets to us as having been successively detached from the sun's equator at the epoch in which this star was only a nebula and stretching out as far as the present orbits of the planets. Thus, for example, at the epoch of the earth's origin the solar nebula extended as far as here and revolved in three hundred and sixty-five days. The centrifugal force developed by this movement on the exterior circumference of the great nebula overpowered for an instant the power of attraction, and this difference was sufficient to detach a ring of vapor, which continued to revolve in three hundred and sixty-five days, while the solar nebula kept on condensing; and then this ring itself condensed into a globe, which became the earth.

The moon was formed from the earth at the epoch in which the latter, extending to her, revolved in twenty-seven days and seven hours, the time required for the centrifugal force to become in equilibrium with gravity. Then from ages to ages, the terrestrial globe, by revolving swifter and swifter, became contracted, according to a well known law of mechanics. At present, the terrestrial equator moves at the rate of about 1,525 feet per second, and develops a centrifugal force which is to the gravity as 1 is to 289. If the earth revolved seventeen times faster, this centrifugal force would be equal to gravity itself, and objects in our equatorial regions would no longer possess any weight. An inhabitant of Quito, who should jump only a few inches high, would not fall back again. No one would adhere to the soil. No living being, no object, nothing would be sustained by its own weight. The least wind would carry everything away. No city even could be built. The equatorial zone would be uninhabitable. The equator would be marked by a ring formed of water detached from the sea, stones detached from the earth, dust detached from the soil, and of objects of every nature. And, if the earth were gaseous and still condensing, the ring thus formed by centrifugal force would soon itself become condensed into a new moon revolving around us in the rapid period of one hour and twenty-four minutes.

It is neither years nor ages that must be reckoned in order to define the immeasurable time that nature must have employed in the elaboration of the mundane system. Millions added to millions scarcely mark the seconds of eternity's clock. But our mind, which grasps time as it does space, sees, hereafter, the worlds born; it sees them at first shining as dull nebulæ, afterwards bursting forth as suns, becoming cool, and covered with spots, and with a solid crust; undergoing subversions and formidable cataclysms, through the frequent falling of the crust into the furnace; becoming scored by numerous cicatrices; then hardening slowly on cooling; receiving externally, thereafter, heat and light from the sun; becoming peopled with living beings; becoming the abode of laboring humanity, which, in its turn, transforms the external surface; and then, after having served as habitations for a superior life and for thought, slowly losing their fecundity, wearing out like the living being itself, reaching old age, decrepitude, and death, and rolling thenceforward like ambulant tombs in the silent deserts of eternal night. During thousands of ages, the terrestrial globe rolled about in space in the state of an immense chemical laboratory. A perpetual deluge of boiling water fell from the clouds upon the burning soil, and ascended again as steam into the atmosphere, again to fall. When the temperature became lower than that of boiling water the aqueous vapor liquefied and was precipitated. In the midst of these fearful tempests, the terrestrial crust, broken thousands of times by the convulsions of the central fire, vomited forth flames and melted; volcanoes thrust up their lava above the level of the warm seas; the first islands made their appearance; and the first semi-fluid combinations of carbon formed the first rudimentary specimens of life, through a substance which scarcely deserves the name of organic, and which, though no longer simply mineral, was yet neither vegetable nor animal. The primitive plants, the algæ, floating inert in the ocean, marked already a progress. Primitive animals, the zoophytes, elementary mollusks, corals, and medusæ, they also marked a progress. From ages to ages the planet imperceptibly lost its crudeness, the conditions of life improved, beings multiplied, and became differentiated from the primitive stock, by acquiring organs which, at first obtuse and rudimentary, became afterwards developed and perfected.

The primordial age alone (during which incipient life was represented only by algæ, crustaceans, and vertebrates as yet without a head) appears to have occupied fifty-three hundredths of the time that has passed from the epoch at which the earth became inhabitable up to our day. The primary period which succeeded it is typified by the establishment of coal vegetation and the reign of fishes, and appears to have occupied the following thirty-one hundredths. The secondary period (during which splendid coniferous plants predominated in the vegetable world, while enormous saurian reptiles reigned over the animal kingdom) lasted the following twelve-hundredths. The earth was then peopled by fantastic beings that were perpetually at war with each other in the midst of the unconquered elements.

So here we have, in the comparative thickness of the strata deposited during these various epochs, ninety-six hundredths of the time that has passed occupied by a living nature absolutely different from that which to-day embellishes our globe—a nature relatively formidable and coarse, as distinct as that of another world. Who then had dared to lift the mysterious veil of time that was to come and divine the unknown future epoch when man was to appear on the newly transformed planet?

The tertiary period (during which we see the advent only of mammiferæ and animal species exhibiting more or less physical affinity with the human race) afterwards comes to gather the inheritance of these primitive ages, and to substitute itself for the preceding period. Its duration has not even risen to three-hundredths of the total time.

Finally, the quaternary age witnessed the birth of the human species and cultivated trees. It does not represent one-hundredth of the total time.

How greatly do these sublime speculations enlarge the ideas that we are habitually forming in regard to nature!

We imagine that we are going back very far into the past when we look at the old Pyramids still standing in the plains of Egypt, the obelisks engraved with mysterious hieroglyphics, the mute temples of Assyria, the antique pagodas of India, the idols of Mexico and Peru, the secular traditions of Asia, and the Aryans, and the implements made of flint—arrows, lances, knives, scrapers, and sling-stones—of our primitive barbarism. We scarcely dare to think of ten thousand—of twenty thousand years. But even should we admit a hundred thousand years as the age of our slowly progressive species, yet what would that be by the side of the fabulous piling up of the ages that have preceded us in the history of the planet?

In allowing only a hundred thousand years to the quaternary age—the age of present nature—we see that the tertiary period would have lasted three hundred thousand years; the secondary period, twelve hundred thousand years; the primary period, more than three millions; and the primordial age, more than five millions of years. Total, ten millions of years. And yet what is this total history of the globe, since something like 350 millions of years were necessary to render the earth solid by lowering its external temperature to 200 degrees? And how many millions would there still have to be added to represent the time that has passed between this temperature of 200 degrees and that of 70 degrees, the probable maximum of the possibility of organic life?

The study of the worlds opens to us in the disposition of times horizons as immense as those that it opens to us in the disposition of space. It makes us perceive eternity as it makes us perceive infinity.

# THE HISTORY OF ALIZARIN AND ALLIED COLORING MATTERS, AND THEIR PRODUCTION FROM COAL TAR.*

By W. H. PERKIN, F.R.S.

## LECTURE I.

IN December, 1868, I had the honor of delivering three lectures before this society on the "Aniline or Coal Tar Colors." In these I commenced with mauveine, or the mauve dye, the first discovered of this remarkable series of compounds, and then gave briefly the history of all the other important coloring matters which had been discovered up to that date.

Last year, Mr. Wills, who always arranged the business of this section so assiduously, wished me to give a further account of these coloring matters, but I was unable to do so then. He, however, asked me again this year, and I was glad to be able to accede to his request, little thinking then, and still less only a few weeks since, when I met him full of activity and enthusiasm, that he would so soon be called from our midst, and his career here, so full of promise, ended.

When I promised to bring a paper before you, I thought that I would continue the history of the coal tar colors, from the time I gave the lectures just referred to up to the present time. However, on considering the subject in detail, I found the amount of matter far too large, owing to the great number of discoveries which had been made in this field since then; I therefore thought it best to confine myself to the consideration of the most important of the products which have been obtained, and selected alizarin and allied coloring matters.

In giving you a somewhat brief account of this subject, I think it best first to refer to madder, the dye stuff which, until 1869, was the only source of alizarin. Up to the date just mentioned madder root was one of the most important dye-stuffs known, the annual value of the imports into the United Kingdom being about £1,000,000 sterling.

The plant that gives this root belongs to the natural order *Rubiaceæ*. It is nearly allied botanically, and in appearance, to the ordinary Galiums, or bedstraws. It is a perennial, with herbaceous stem, which dies down every year, the stalk is square and jointed, and this and the leaves are rough with prickles. The flower is very small and of a greenish yellow color. The root is cylindrical and fleshy, and of a reddish yellow color; this, when dried, constitutes madder. It is one of the oldest known dye-stuffs, and is referred to by Pliny. The principal varieties in cultivation are—*Rubia tinctorum*, *Rubia peregrina*, and *Rubia cordifolia*. It is grown in Holland, South of Germany, France, Italy, Turkey, and India. It has been cultivated also in this country, but not with permanent success. It is propagated from suckers, and the time from planting until the roots are drawn is from eighteen to thirty months, and sometimes longer. When dried, the roots lose their reddish yellow color, and become of a pale red shade. The process of drying is conducted in the air, or in kilns. When dry, the roots are beaten to remove sand, clay, and loose skin. It is sent into the market either in this condition or in a ground state. There are also various preparations of madder made, the principal ones being *fleur de garance*, or flowers of madder, and *garancine*. Their preparation is briefly as follows:

*Fleur de garance* is made by soaking ground madder in water, with the addition of a small quantity of sulphuric acid; it is then drained in a filter and well washed. The washings contain a considerable amount of glucose, besides other products, and when fermented yield alcohol, which is suitable for a variety of purposes, but is not fit for drinking unless purified. The washed madder is then pressed and dried, and constitutes *fleur de garance*. On account of the products which have been removed, this substance is considerably richer in coloring matter than madder.

*Garancine* is prepared by first washing ground madder, much in the same way as for the preparation of *fleur de garance*, and after being pressed it is mixed with concentrated sulphuric acid, in quantity equal to about half the weight of the madder originally taken. After being thoroughly incorporated with this, it is heated with steam for three or four hours, placed on filters, and thoroughly washed, pressed, and dried. Tinctorially it is about three and a half times as strong as madder.

Madder will not dye unprepared fabrics; they require to be what is called mordanted. In this case the mordants consist of metallic oxides, those of aluminum and iron being the chief ones. With alumina mordants it produces shades of red and pink, with iron mordants shades of black and purple. These mordants may likewise be mixed, and then produce various kinds of chocolate color. The value of madder, and its preparations, is determined by taking weighed quantities, and dyeing pieces of mordanted cloth with them, the size of the cloth being always the same; after dyeing the patterns are cleared by treatment with soap, and are then dried; and, of course, according to the depth of the color, so is the value. Standard specimens are used at the same time for the sake of comparison.

In mordanting cotton goods, the mordants, which are chiefly the acetates of iron and aluminum, are thickened and printed on, either with a machine or blocks. They are "aged," as it is called. This used to be performed by hanging the goods in a moist atmosphere for some days, but now they are passed through properly constructed rooms, kept at the requisite temperature and degree of moisture by steam, and then laid in bundles for a time.

The next process is called "dunging." Its object is to remove the thickening which has been used with the mordants, and also to thoroughly neutralize them, at the same time removing any that has not combined with the fiber. This is accomplished by passing the goods through warm water containing cow dung, but now more commonly containing certain salts, as phosphates, arseniates, etc.; these are called dung substitutes. When this operation has been finished the goods are washed, and are then ready for dyeing.

Dyeing with madder is an operation requiring considerable care, especially as the temperature of the dye bath must be raised only very slowly, otherwise a loss of coloring matter occurs. This makes the operation take some considerable time, often two hours. If garancine is used, the dyeing can be conducted more quickly. In this operation the ground madder or the garancine is mixed with the water in the dye bath. A little chalk is also sometimes added. As the coloring matter of the dye stuff gradually dissolves in the water, the mordants on the goods take it up. It is important in this process that the mordants should be thoroughly saturated with coloring matter, otherwise they do not resist the after clearing processes so well. When dyed, the goods are washed with water and then cleared, as most of the colors are very impure, especially the reds, which have a rusty look. The methods of clearing vary according to the class of goods, madder pinks receiving the greatest amount of treatment and care. In this process soap is largely used, but it will not be necessary to enter into further details, as it would occupy too much time, and I only wish to convey to you a general impression of the application of madder to calico printing.

Before leaving this subject, I must refer to another most important application of madder, namely, Turkey red dyeing. This mode of dyeing was introduced into Europe from the East, and is undoubtedly of Indian origin; from India it came to the Levant, and was afterwards introduced into France in 1747. The first Turkey red works in the United Kingdom were established about the end of the last century. Turkey red is remarkable for its brilliancy of color and permanence, and also for the peculiar nature of the processes employed in its production.

For dyeing Turkey red, the cotton is first prepared by treatment with olive oil, which is afterwards oxidized by exposure to the air. The oil is usually employed in the form of an emulsion, made by agitating the oil with a solution of carbonate of soda or potash. The goods are passed through this, and then exposed to the air, after which they are treated several times in the same manner. When sufficiently charged with oxidized olive oil, they are mordanted with an alumina salt, galls, sumac, or other tannin matter. Cotton thus prepared for dyeing is of a buff or a yellowish shade.

In the next operation, the dye-bath is charged with madder or garancine, a little sumac, and a quantity of blood. The prepared goods are entered into this bath, and heat gradually applied until it reaches the boiling point, at which temperature it is kept until the dyeing is complete. The goods are then washed in water, and present a dark, heavy, dull red color. They are next subjected to the clearing processes, which are two in number. These are performed in large copper boilers, with movable covers, as the clearing has to be done under pressure. The dyed goods are placed in these, with a mixture of common soda crystals and soap, and boiled under pressure for about six hours. They are then removed, washed in hot water, and again placed in boilers, with a solution of soap, to which chloride of tin (tin crystals) has been added. They are boiled in this, under pressure, for about four hours, and then removed, washed and finished. The first clearing considerably improves the color, but the last one gives that remarkable brilliancy peculiar to good Turkey red. After all this treatment with soap, we can understand that Turkey red is a very fast color.

No satisfactory process for printing Turkey red has yet been found. Some time since I made a few experiments on the subject. The cloth prepared ready for dyeing was used, and then printed with the coloring matter; it was then steamed, washed, and cleared as above. The colors were very good indeed, but the parts which should be white were still of the yellowish color of the prepared cloth.

When a Turkey red is wanted in a pattern, the cloth is first dyed all over with this color. If white is required in the pattern, those parts are printed with thickened tartaric acid; if yellow, with tartaric acid and a lead salt; if blue, with tartaric acid and Prussian blue. On passing cloth printed in this manner into a solution of chloride of lime, the parts printed with acid, as they come in contact with this solution, cause chlorine to be evolved, and the Turkey red destroyed, thus white is produced. If blue has been printed on with the acid, the red being discharged, blue remains. If a lead salt has been printed on, white is obtained; but when passed through a solution of bichromate of potash, yellow chromate of lead is formed. Of course green can be obtained by combining the last two processes. Black is printed on direct. Most beautiful results are obtained in this manner.

Madder is also employed in woolen goods. It is generally used in combination with other dyestuffs, for the purpose of producing brown, buff, or chocolate colors. But I must pass on, the application of madder being a subject on which books have been written; any remarks are therefore necessarily of only a very general character, though I hope sufficient to give some idea of the processes.

Having seen the importance of madder as a dyestuff, and the methods of applying it to fabrics, it will next be desirable to consider the coloring matters it contains, which render it so valuable.

Scarcely anything was known of these until 1827. At this date, two chemists, Colin and Robiquet, obtained the principal coloring matter in a state of tolerable purity. They extracted ground madder with hot water, and, after treating this extract in various ways, obtained a product which, when heated carefully in a glass tube, gave off a yellowish vapor, condensing into brilliant bright-red needles. They named this substance *Alizarin*, from the Levant name of madder, *Alizari*.

But the method they adopted for the preparation, viz., sublimation, rendered it a matter of uncertainty whether alizarin pre-existed in madder, or was a product of decomposition of some other body. Dr. Schunck, however, afterwards succeeded in obtaining it without having recourse to sublimation. If further proof were needed, it was found in the fact that the coloring matter was capable of dyeing mordanted cloth, just in the same way as madder. It exists in madder in only very small quantities, not more than to the extent of one per cent.

Alizarin is nearly insoluble in cold water, and 1,000 parts of boiling water dissolved only about three parts of the coloring matter. It is more soluble in alcohol, and from high boiling naphtha it may be crystallized in red needles. When crystallized from alcohol, it is obtained in orange-colored needles.

One of the characteristic properties of alizarin is the beautiful blue violet solution it produces on being dissolved in caustic alkalies. This solution, when viewed by the spectroscope, shows two strong absorption bands, one near to C, and the other at D, and a very faint one near to E. Alizarin also dissolves in ammonia with a purple color. It forms a red lake with alumina, and a black one with oxide of iron.

Curiously, alizarin is not found in the growing madder root. This is easily seen by expressing some of its juice, and treating it with caustic potash. In this way a red-colored solution is produced, and not a violet one, as would be the case if alizarin were present. This coloration is due to the presence of a substance called *rubianic acid*. This body is a glucoside of alizarin, and when decomposed yields alizarin and glucose. This can be easily effected by boiling it with hydrochloric acid, when alizarin separates as a yellow precipitate. Rubianic acid does not possess dyeing properties.

The decomposition of this glucoside in the madder root occurs partly during the process of drying, but not entirely until it is gently heated with water in the dye-bath. This decomposition is caused by a peculiar ferment called *Erythrozyme*, a product which is destroyed if heated with water to 100° C. This is one reason why the madder dyers have to gently raise the temperature of their dye-bath, so that this glucoside may entirely decompose, and all the alizarin be liberated and rendered useful. The importance of this may be easily seen, by taking two equal parts of growing madder root, and, after bruising them in a mortar, to throw one into boiling water, and the other into cold water. On placing a piece of mordanted cloth in each, keeping the one with boiling water still boiling, and gradually raising the temperature of the other, it will be found that the one in boiling water will have scarcely colored the mordants, whilst the one in cold water and gently warmed up will have dyed them thoroughly.

There is only one other coloring matter in madder that I need refer to, and that is purpurin. This substance was discovered by Colin and Robiquet, and called by them *Matière colorante rose*. It was afterwards obtained in a somewhat purer state by Debus, and by Wolff and Strecker. This substance is separated from madder by boiling it with a solution of alum; munjeet, however, is its best source. It is precipitated from the alum solution with hydrochloric acid and then further purified. When pure purpurin crystallizes in red or orange-red needles, it differs from alizarin in the way it behaves with alkalies, solutions of these yielding with it beautiful cherry-red colors. It also dissolves in alumina salts with formation of pink solutions, which are fluorescent. The spectrum is also very different from that of alizarin.

It dyes mordanted cloth, forming with alumina mordants a yellowish scarlet. The colors it produces with iron mordants, however, are not at all good. The purpurin colors do not resist soaping well, so that the madder prints, in the process of clearing, lose all the purpurin taken on in the dye-bath. It is retained, however, to some extent in the cheaper class, such as garancine styles. From this it will be seen that it is a substance of but little value. It exists in the growing madder root as a glucoside.

A great deal of controversy has taken place respecting the chemical formula of alizarin. Dr. Schunck proposes $C_{14}H_{10}O_4$, which according to the present notation would be $C_7H_5O_2$, whilst Strecker believed it to be $C_{14}H_8O_3$, and related to chloroxynaphthalic acid, a derivative of naphthalene, so that it has long been supposed that it was possible to obtain alizarin from a coal-tar product, though not from the right one. Still there was a good deal of reason to believe that it was a naphthalene derivative, from the fact that when oxidized it yields the same acid as naphthalene, namely, phthalic acid. Strecker's formula was the one generally believed in. It is right to mention that Strecker changed his views of this subject afterwards.

The chloroxynaphthalic acid above referred to was supposed to be a chlorine derivative of alizarin, the two bodies being thus related:

| $C_{14}H_8O_3$ | $C_{14}H_5Cl\,O_3$ |
|---|---|
| Alizarin. | Chlorinated Alizarin. |

And many attempts were made to remove this chlorine, and replace it by hydrogen, so as to form alizarin; and eventually Martius and Greiss obtained the substance, $C_{14}H_8O_2$, when investigating some amido derivatives of naphthol, but it was not alizarin. They assumed it, however, to be an isomer of that body.

Some time after the experiments of Martius and Griess, Graebe commenced some researches on quinone (a body related to benzene). At that time no analogous substance to quinone, related to any other hydrocarbon than benzene, was recognized. However, he was induced to consider chloroxynaphthalic acid as a derivative of a naphthalene quinone, which has since been obtained, and also discovered a chlorinated derivative of a quinone of toluene.

The attention of Graebe, in conjunction with Liebermann, was then turned to alizarin, which they thought probably might belong to the quinone series; but it was important that they should first know as to what hydrocarbon it was related. To obtain that information, alizarin prepared from madder was taken and heated with powdered zinc, according to Baeyer's method of reducing aromatic compounds, and in this manner they obtained a crystalline hydrocarbon, having the composition, $C_{14}H_{10}$. This was shown to be anthracene, a hydrocarbon contained in coal tar. Reasoning from the information which they had thus obtained, they assumed alizarin to be a dioxyquinone acid of anthracene—

| $C_{14}H_{10}$ | $C_{14}H_8O_2$ | $C_{14}H_6\left(\begin{matrix}OH\\OH\end{matrix}\right)O_2$ |
|---|---|---|
| Anthracene. | Anthraquinone. | Alizarin. |

But, to prove this to be the case, it was necessary to produce alizarin from anthracene.

This hydrocarbon was discovered by Dumas and Laurent in 1832. They obtained it from the product which comes over towards the end of the distillation of coal tar. They gave it the formula $C_{15}H_{12}$, and as this was one and a half times the molecular weight of naphthalene, they called it paranaphthalene. It was further examined by Laurent, who changed its name to anthracene. He also obtained from it a body which he called anthracenuse, by oxidizing it with nitric acid; to this he gave the formula $C_{15}H_8O_4$ and $C_{15}H_7O_4$.

In 1854–55, when studying under Dr. Hofmann, at his suggestion, I took up the subject of anthracene for my first investigation. I prepared the hydrocarbon by distilling pitch. Dr. Hofmann afterwards kindly obtained for me, from Messrs. Bethel, several pounds of a product rich in anthracene. On oxidizing anthracene, I obtained a product to which I assigned the formula $C_{14}H_{10}O_2$, and not doubting Laurent's formula for the hydrocarbon anthracene, believed this oxygenated product to be derived from it by loss of carbon and hydrogen. These results were not published, and I only mention them here because it was through the experiments I then made that I obtained much information, which afterwards proved to be of great value to me; and, moreover, the products I then made served for the experiments to which I shall have to refer presently.

In 1857, Fritsche examined a hydrocarbon from coal tar, to which he gave the formula $C_{14}H_{10}$, and showed that it had many properties in common with anthracene.

In 1862, Dr. Anderson published an account of his investigations on anthracene. He found it to possess the formula $C_{14}H_{10}$, and to be identical with Fritsche's hydrocarbon. Dr. Anderson also prepared the oxidation product, and found it to contain $C_{14}H_8O_2$. He called it oxanthracene; it is identical with Laurent's anthracenuse, and with the product I obtained.

Graebe and Liebermann at once recognized this as the quinone of anthracene. It, therefore, only remained for them to convert this into the quinone acid, by replacing two atoms of hydrogen by hydroxyl, and thus settle the question as to whether alizarin be a quinonic acid of anthracene or not.

The process they adopted has long been used by chemists;

* Two recent lectures delivered before the Society of Arts, London.

it consists in first replacing the hydrogen of the compound with bromine or other halogen, and then treating the resulting body with sodic, potassic, or other metallic hydrate, and according as one, two, or more atoms of hydrogen have been replaced by bromine, so on its removal by the metal of the hydrate, a compound containing a corresponding number of atoms of hydrogen replaced by hydroxyl is obtained.

Acting upon this principle, Graebe and Liebermann heated anthraquinone in sealed tubes, with bromine, in the proper proportions to obtain a dibromanthraquinone, $C_{14}H_6Br_2O_2$. And this substance, when fused with caustic potash, yielded alizarin in combination with the alkali, from which it was separated by means of an acid. They also proposed a second method for preparing dibromanthraquinone, viz., by oxidizing tetrabromanthracene.

$$C_{14}H_6Br_4+O_2=C_{14}H_6Br_2O_2+Br_2$$

The great importance of alizarin, as a dyeing agent, induced Graebe and Liebermann to patent their process, but it was of no commercial value. They had, however, solved the question of the relationship to anthracene and anthraquinone, and also established its formula—

$$C_{14}H_6\begin{pmatrix}OH\\OH\end{pmatrix}O_2$$

Strecker, in 1866, had given the correct formula for alizarin, but did not publish it in the ordinary way results of research are usually published, but adopted it in his "Traité de Chimie Organique." And it was not until he drew my attention to the fact, that I became aware of it. He also states that he instituted experiments in 1855, in conjunction with Staedel, to establish the relationship between alizarin and anthracene. Graebe and Liebermann appear to have had no knowledge of this.

On distilling purpurin, the other coloring matter of madder previously referred to, Graebe and Liebermann also obtained anthracene, and this confirmed the formula Strecker had assigned to this substance, viz., $C_{14}H_8O_3$.

Purpurin is anthraquinone, with three atoms of hydrogen replaced by hydroxyl.

$$C_{14}H_5\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right\}O_2$$

Graebe and Liebermann's process for the preparation of alizarin being found to be impracticable, it was desirable, if possible, to find a new method which would render their discovery of commercial value.

It has been known for a very long time, that sulphuric acid acts upon many organic bodies, producing substances called sulpho-acids. In composition, these represent the body acted upon *plus* sulphuric anhydride, the basicity of the product (if derived from a neutral body) increasing with the number of molecules of sulphuric anhydride used in its formation. These so called sulpho-acids have been found, however, to be nothing more than acid sulphites; thus, the acid produced by the combination of benzol with one molecule of sulphuric anhydride, is an acid sulphite of phenyl, or phenylsulphurous acid:

$$\underbrace{C_6H_6SO_3}_{\text{Sulphobenzolic acid.}} = \underbrace{C_6H_5SO_2H}_{\text{Phenylsulphurous acid.}}$$

And that obtained by combining naphthalin with two molecules of sulphuric anhydride, is an acid disulphite:

$$\underbrace{C_{10}H_8(SO_3)_2}_{\text{Disulphonaphthalic acid.}} = \underbrace{C_{10}H_6\left\{\begin{matrix}SO_2H\\SO_2H\end{matrix}\right\}}_{\text{Naphthylene-sulphurous acid.}}$$

The experiments of Würtz and Kekulé, in 1867, confirmed this view of the constitution of these acids. They found that sulphobenzolic acid, when heated with caustic potash, produced a phenate and sulphite, thus:

$$\underbrace{C_6H_5SO_2H}_{\text{Sulphobenzolic acid.}}+3KHO=\underbrace{C_6H_5OK}_{\text{Potassic phenate.}}+SO_3K_2+2OH_2$$

In the same year Dusart also found that disulphonaphthalic acid yielded in the same way a naphthylenate and a sulphite:

$$\underbrace{C_{10}H_6\left\{\begin{matrix}SO_2H\\SO_2H\end{matrix}\right\}}_{\text{Disulphonaphthalic acid.}}+6KHO=\underbrace{C_{10}H_6\left\{\begin{matrix}OK\\OK\end{matrix}\right\}}_{\text{Potassic naphthylenate.}}+2SO_3K_2+4OH_2$$

By the addition of an acid to the products of these reactions, they obtained first from benzol, by means of the sulpho-acid, hydrate of phenyl, phenol or carbolic acid, and from naphthylene, the dihydrate of naphthylene:

| | |
|---|---|
| $\underbrace{C_6H_6}_{\text{Benzol.}}$ | $\underbrace{C_6H_5OH}_{\text{Hydrate of phenyl.}}$ |
| $\underbrace{C_{10}H_8}_{\text{Naphthylene.}}$ | $\underbrace{C_{10}H_8\left\{\begin{matrix}OH\\OH\end{matrix}\right\}}_{\text{Dihydrate of naphthylene.}}$ |

In this second example, it will be seen that we have obtained a body standing to naphthylene as alizarin does to anthraquinone. In other words, two atoms of hydrogen have been replaced by two hydroxyls.

It therefore appeared probable to me that, if a disulpho acid of anthraquinone could be produced, alizarin might possibly be obtained by a similar process.

From my previous knowledge of the remarkable stability of anthraquinone, and that it might be dissolved in strong hot sulphuric acid, and would then crystallize out unchanged on cooling, it did not appear very probable that a sulpho acid could be formed; nevertheless, experiments were made, varying temperatures being employed, when eventually it was found that by heating a mixture of sulphuric acid and anthraquinone very strongly, combination actually took place, the mixture becoming perfectly soluble in water. After removing the excess of sulphuric acid from the new product, it was mixed with caustic potash, and heated to about 180° C.; it soon became colored, and then black. When the reaction was considered complete, the black alkaline mass was dissolved in water, and formed a rich purple solution. On acidifying this, it became yellow, from the separation of a copious precipitate, which, on examination, proved to be artificial alizarin. This product, when collected on a filter and thoroughly washed, was found to dye madder mordants with the greatest readiness.

The great obstacle to the preparation of alizarin, viz., the use of bromine, was thus removed, and, as the future has proved, a process had been obtained by which this coloring matter could be manufactured in quantity.

I may here mention that, while these experiments were in progress, Caro, Graebe, and Liebermann were investigating the same reaction in Germany.*

A short time after I had discovered this method of making artificial alizarin, I found an entirely new process, in which anthraquinone is not required at all.†

Anthracene forms with chlorine a beautifully crystalline body, called dichloranthracene, having the formula, $C_{14}H_8Cl_2$. This substance combines with Nordhausen sulphuric acid, forming a bright green solution, which consists of a sulpho acid of dichloranthracene. This compound undergoes a remarkable change when heated with sulphuric acid, hydrochloric acid and sulphurous anhydride being evolved, and a sulpho acid of anthraquinone formed. This process has proved to be of great value, as will be seen further on.

When artificial alizarin was first manufactured it was noticed that the colors produced by it differed, to some extent, from those produced with madder or alizarin. The red shades were more brilliant and more scarlet and the purples bluer; the blacks were also more intense, and some persons went the length of saying that alizarin had not been produced artificially at all. This I refuted in a paper read before the Chemical Society in May, 1870,‡ when I showed that alizarin could be readily separated from the commercial product, and then possessed all the properties of natural alizarin, both as regards its dyeing power and in its other characteristics. As no doubt now exists on this point, I think I need not further discuss it.

In a foot note§ in the paper just referred to I stated that "when purifying artificial alizarin by converting it into an alumina lake, I found that, upon digestion with carbonate of potash, this lake gave a red colored solution, containing a coloring matter dyeing mordants very similarly to alizarin, with the difference that the reds were more scarlet, and the purples bluer or more slaty. I have not obtained this body in a perfectly pure state as yet, but it appears to be crystalline. It gives two faint black bands when examined in alkaline solution with the prism, but these may perhaps be due to the presence of traces of alizarin." Some time after this I made a complete examination of this substance,‖ and my analytical results showed it to have the same composition as natural purpurin, viz.:

$$C_{14}H_5\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right\}O_2,$$

though it differs from it in properties, in fact, it is an isomeride of that substance. Being a derivative of anthracene, I therefore named it anthrapurpurin. Auerbach,¶ in 1872, separated a coloring matter from artificial alizarin. He named it isopurpurin. It is, however, identical with anthrapurpurin. The name isopurpurin is now mostly used for this substance on the continent.

The importance of anthrapurpurin as a coloring matter can scarcely be over-rated. I believe I may truly say it is of as great importance as alizarin itself, and its existence in artificial alizarin has been the cause of its marvelously rapid success, as it gives a brilliancy to the reds which cannot be obtained with madder. Anthrapurpurin differs from alizarin in many particulars. When heated it is mostly decomposed, only a little subliming in orange-red vapors, and condensing as yellowish red leaves. If a mixture of anthrapurpurin and alizarin be sublimed the sublimate will consist almost entirely of alizarin, as this substance is not so easily decomposed by heat.

Anthrapurpurin dissolves in caustic alkalies with a more purple color than alizarin. It also differs in its behavior with alumina. A solution of anthrapurpurin in sodic carbonate, when mixed with freshly precipitated alumina, is not absorbed by it, whereas alizarin under the same conditions is perfectly absorbed. It crystallizes in orange yellow needles, from alcohol or glacial acetic acid.

By heating it with acetic anhydride I obtained a triacetyl derivative, and, by using benzoyl chloride, a tribenzoyl one, thus showing it to contain three replaceable hydrogens. Its alkaline solutions give two faint absorption bands when viewed with the spectroscope, these bands being in the same region of the spectrum as those produced with alkaline solutions of alizarin. When oxidized with nitric acid it does not yield phthalic acid.

On heating anthrapurpurin with ammonia to a temperature of 160–180° C., in a closed tube, I found it changed into an amidated compound, which has been named anthrapurpuramide. This substance does not dye mordants. Its solution in alcohol is of a clear dark orange-red color. It dissolves in alkalies with a purple color. Anthrapurpuramide is isomeric with amido-alizarin. Its formula is:

$$C_{14}H_5\left\{\begin{matrix}NH_2\\OH\\OH\end{matrix}\right\}O_2$$

In my paper on anthrapurpurin, it is mentioned that there is a coloring matter in artificial alizarin dyeing alumina mordants of an orange color.** This was afterward obtained in a crystalline condition, and was under investigation for some time, but the research was laid aside on account of more pressing subjects. This substance, however, proves to be flavopurpurin, a coloring matter lately described by Schunck and Roemer,* and obtained by them from anthraflavic acid. It has the formula—

$$C_{14}H_5\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right\}O_2,$$

and is therefore isomeric with anthrapurpurin.

The amount of it contained in artificial alizarin is not very large. It is much more freely soluble in alcohol than anthrapurpurin, and crystallizes from that solvent in orange-colored silky needles. Its alcoholic solution, when poured into water, forms a yellow precipitate; this, however, has a satiny aspect, owing to the crystalline character of the precipitate; it dissolves in caustic alkali with a purple color, redder than that produced with anthrapurpurin, and in ammonia it forms a brownish-red color, anthrapurpurin forming a purple solution.

Flavopurpurin dyes mordants, but the colors on those of alumina are of an orange-red color, the pinks being somewhat of a salmon shade. The purples are more like those of alizarin, but very dull in comparison with them.

In artificial alizarin, I believe there is yet another coloring matter not investigated—dyeing alumina mordants a still yellower shade than flavopurpurin. It is apparently present in very small quantities.

We now see that the product at first made, and called "artificial alizarin," contained at least three coloring matters, viz., alizarin, anthrapurpurin, and flavopurpurin; as I think it will be convenient to retain this name at present for simplicity sake, it will be understood that, when I use it, I do not refer to pure alizarin, but to commercial products known by that name.

Before proceeding to speak of some of the products found in artificial alizarin, I wish to draw attention to a soluble intermediate substance which is obtained in its preparation, if the process of heating with caustic soda be not carried on sufficiently long. In this case, although the alkaline product dissolved with a strong violet color, I noticed that, when acidified, no coloring matter, or only a small quantity, was precipitated, a strong dark yellow solution being obtained. On isolating this body, it was found to be crystalline, forming orange-colored needles, easily soluble in water, but insoluble in ether. With alkalies, it forms a blue violet-colored solution; it does not dye mordants. When fused with caustic alkali it is converted into anthrapurpurin. From the mode of its formation, and from its decomposition with alkalies, I gave it the formula—

$$C_{14}H_6\left\{\begin{matrix}OH\\SO_3H\end{matrix}\right\}O_2$$

and named it sulphoxanthraquinonic acid.† Some time afterward Graebe and Liebermann‡ further investigated this compound, and confirmed this formula. With the alkaline earths it forms two sets of salts—acid and neutral ones—the former being of a yellow color; the latter violet. These probably could be used as pigments.

The artificial alizarin, as first made, contained not only three coloring matters, but also other products not possessing dyeing powers. These are of considerable interest, as will be seen further on. Among these are anthracene, anthraquinone, and hydroanthraquinone, products which are the result of a peculiar reverse action, or process of reduction, which takes place in the preparation of artificial alizarin during the operation of heating with caustic alkali. The first, viz., anthracene, was only formed in the early experiments, and resulted from overheating. But the two other substances are always obtained if caustic alkalies alone are used. Of anthraquinone I have already spoken, but I have not referred to the action of reducing agents upon it. If anthraquinone be mixed with a solution of caustic potash and zinc dust the liquid quickly becomes red, especially if heated, the anthraquinone dissolving. This liquid may be filtered; but as the oxygen of the air quickly acts upon it, films of anthraquinone are formed; if the air be excluded, a clear red-colored fluid is obtained, and, on the addition of an acid, a yellow precipitate is formed. This substance is hydroanthraquinone, produced from anthraquinone by its union with hydrogen. Its formation may be represented thus:

$$\underbrace{C_{14}H_8O_2}_{\text{Anthraquinone.}}+H_2=\underbrace{C_{14}H_{10}O_2}_{\text{Hydroanthraquinone.}}$$

The other bodies I have to speak of are not due to any reverse chemical action, but are the products of direct changes, and were regarded as secondary products.

On boiling up artificial alizarin with dilute caustic soda and adding milk of lime, it was found that the coloring matter was precipitated, leaving a yellow or orange-colored solution. On filtering this off and adding an acid to the filtrate, a pale yellow precipitate was obtained. A quantity of this was prepared, washed, and dried, and from some of it Dr. Schuncks§ succeeded in isolating a beautifully yellow crystalline product. This he called anthraflavic acid, and assigned to it the formula, $C_{14}H_{10}O_4$. Not being satisfied with this formula, I afterward submitted it to investigation,‖ and showed it to have the composition, $C_{14}H_8O_4$, which has since been confirmed by others. This formula is the same as that of alizarin, and, therefore, anthraflavic acid is an isomeride of that substance. It is prepared from its barium salt, which is somewhat difficultly soluble in water.

Anthraflavic acid is a beautiful substance, crystallizing in bright yellow silky needles, and, when heated, gives a sublimate of golden yellow crystals, in the form of leaves or plates, a certain amount being at the same time carbonized. It does not dye mordants. It combines with alkalies, forming compounds, dissolving in water with an orange-red color. The barium salt, already referred to, crystallizes in needles of a brownish-red color, and its cold aqueous solution is somewhat similar in appearance to that of potassic bichromate.

Dr. Schunck found that anthraflavic acid, when fused with caustic potash, was converted into a coloring matter, which he thought to be alizarin. I also believed this to be the case until some time afterward, when I prepared a sufficient quantity of the coloring matter to dye a pattern with. I then found it produced orange-red colors with alumina mordants.¶

Schunck and Roemer** have since investigated this reaction, and found that the coloring matter is an isomer of anthrapurpurin; in fact, it is flavopurpurin, which has al-

* Graebe and Liebermann, in a paper published in the *Moniteur Scientifique*, April, 1879, p. 289, state that "Caro was the first to observe that anthraquinone, when heated with sulphuric acid above 200°, formed sulphoconjugated acids, which, like the brominated compound, gave alizarin on fusion with potassium hydrate; soon afterward, or almost at the same time, Perkin made the same observation." Again, at pp. 400-401, they state: "The patent of Caro, Graebe, and Liebermann is dated a day before that of Perkin. If any particular importance is attached to dates, the advantages rest without dispute with Caro, for the filing of the patent of the German chemist was delayed through irregularity (*vice de forme*). The signatures had already been given in to the Patent Office, Berlin, on the 15th June." I may remark, in reference to the first statement, that Graebe and Liebermann neither give nor adduce any evidence to substantiate their claim to priority. Their remark that I had soon afterward, or almost at the same time, made the same observation, also goes to show that they have none. And in reference to the statement that their signatures had been given in to the Patent Office, Berlin, on the 15th June, I found that on May 20th I wrote to Mr. Robert Hogg, of Glasgow, inclosing patterns dyed with artificial alizarin, which I had prepared by fusing the sulphoconjugated acids of anthraquinone with potassium hydrate, and my patent might then have been secured, but was delayed. Therefore their conclusions, from the argument as to dates, should be reversed.

† Patented November, 1869, No. 3318.

‡ *Journal of the Chemical Society*, 1870, p. 133.

§ *Journal of the Chemical Society*, 1870, p. 143.

‖ *Journal of the Chemical Society*, 1872, p. 659; 1873, p. 425.

¶ *Moniteur Scientifique*, 1872, p. 686.

** *Journal of the Chemical Society*, 1873, p. 425.

* *Deut. Chem. Ges. Ber.*, 1878, p. 679.

† *Journal of the Chemical Society*, 1870, p. 139.

‡ *Jahresbericht*, 1871, p. 685.

§ Proc. Lit and Phil. Soc., Manchester, vol. x., p. 133.

‖ *Journal Chemical Society*, 1871, p. 1109.

¶ *Journal of the Chemical Society*, 1873, p. 20.

** *Deut. Chem. Ges. Ber*, 1876, p. 679.

rendy been described. Its formation may be expressed thus:

$$\underbrace{C_{14}H_6O_4}_{\text{Anthraflavic acid.}}+3OKH=\underbrace{C_{14}H_5K_3O_5}_{\text{Potassic flavopurpurate.}}+H_2+2OH_2$$

To effect this change in small experiments, a temperature of over 200° C. is necessary.

Dr. Schunck and H. Roemer* have published an account of another substance which accompanies anthraflavic acid. They have named it isoanthraflavic acid. I had also succeeded in obtaining this substance, and also in preparing it without the formation of coloring matter, except in small quantities.† To this I shall refer presently.

Isoanthraflavic acid crystallizes from glacial acetic acid, in which it is difficultly soluble, in yellow needles. These lose their luster on being dried at 100° C. When strongly heated it sublimes in leaves of a golden or orange color. This substance has the formula—

$$C_{14}H_6\left\{\begin{matrix}OH\\OH\end{matrix}\right\}O_2$$

and is, therefore, another isomer of alizarin. It differs from anthraflavic acid in forming a barium derivative, which is easily soluble in cold water with a dark red color. Heated with acetic anhydride, it forms a pale yellow crystalline body, having the formula—

$$C_{14}H_6\left\{\begin{matrix}OC_2H_3O\\OC_2H_3O\end{matrix}\right\}O_2$$

Diacetoisoanthraflavic acid.

When heated to about 180° C. with caustic potash it undergoes a very interesting change. The mixture gives a black-looking product, which dissolves in water with a beautiful purple color. On acidifying this with an acid, a yellow precipitate is formed, which is found to consist of anthrapurpurin. This change is similar to that which takes place when anthraflavic acid is treated with caustic alkalies, but occurs at a much lower temperature. This reaction is as follows:

$$\underbrace{C_{14}H_6O_4}_{\text{Isoanthraflavic acid.}}+3OKH=$$

$$\underbrace{C_{14}H_5K_3O_5}_{\text{Potassic anthrapurpurate.}}+H_2+2OH_2$$

Isoanthraflavic acid does not dye mordants.

Another substance was found in artificial alizarin, as a by-product, by Caro and Glaser. It was first examined in 1871 by Liebermann,‡ who found it to have the formula—

$$C_{14}H_7(OH)O_2$$

and named it monoxanthraquinone. It crystallizes from alcohol in fine yellow needles. It does not dye mordants.

Monoxanthraquinone, when fused with alkalies, also undergoes an interesting change. It becomes a nearly black mass, which dissolves in water with a blue-violet color, and this solution, on being acidified, gives a yellow precipitate, which is nothing but pure alizarin.

$$\underbrace{C_{14}H_7(OH)\,O_2}_{\text{Monoxanthraquinone.}}+2OKH=$$

$$\underbrace{C_{14}H_6\left\{\begin{matrix}OK\\OK\end{matrix}\right\}O_2}_{\text{Potassic alizarate.}}+H_2$$

Now, how can the presence of monoxanthraquinone, anthraflavic, and isoanthraflavic acid in artificial alizarin be accounted for? When sulphuric acid acts upon anthraquinone, two kinds of sulpho acids are formed, namely, a mono and a di:

$$\underbrace{C_{14}H_7(SO_3H)O_2}_{\text{Monosulphanthraquinonic acid.}}\qquad\underbrace{C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}O_2}_{\text{Disulphanthraquinonic acid.}}$$

After the manufacture of alizarin had been commenced, Graebe and Liebermann published an account of these bodies.§

They found that monosulphanthraquinonic acid, when heated carefully with alkali, yields monoxanthraquinone.

$$C_{14}H_7(SO_3H)O_2+3OKH=$$
$$\underbrace{C_{14}H_7(OK)O_2}_{\text{Potassic monoxanthraquinonate.}}+SO_3K_2+2OH_2$$

And this, when further heated, yielded alizarin, as previously stated. The disulpho acid, when heated with alkali, they said, formed alizarin:

$$C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}O_2+6KHO=$$
$$C_{14}H_6\left\{\begin{matrix}OK\\OK\end{matrix}\right\}O_2+2SO_3K_2+4OH_2$$

This, as we shall see presently, was a mistake, probably from the fact that the need of a disulpho acid for the preparation of alizarin had never been doubted, the process being supposed to be analogous to that originally described with dibromanthraquinone.

But it was gradually found, when manufacturing artificial alizarin on the large scale, that, the smaller the amount of sulphuric acid used to convert the anthraquinone into sulpho acids, the temperature being also kept as low as practicable, the coloring matter made from such a product yielded with mordants shades of color more nearly approaching those produced with madder, until eventually the unexpected result was arrived at, that it was necessary to have a monosulpho acid of anthraquinone for the preparation of pure alizarin, and that the disulpho acid does not yield this substance at all, so that, in the preparation of pure alizarin, the following reactions take place: monosulphanthraquinonic acid is first decomposed into monoxanthraquinone; and this, when further heated with alkali, is oxidized into alizarin.

We thus see that this formation of alizarin differs entirely from that originally discovered by Graebe and Liebermann, both as regards the chemicals employed and the chemical changes which take place. We also see that monoxanthraquinone is an intermediate product and not a secondary one.

Disulphanthraquinonic acid, although it does not yield alizarin when heated with alkalies, yields anthrapurpurin. But how is this to be accounted for? It has been shown that the first action of caustic alkali on this acid results in the formation of sulphoxanthraquinonic acid:

$$C_{14}H_6\left\{\begin{matrix}OH\\SO_3H\end{matrix}\right\}O_2$$

This, when further treated with the same reagent, changes into anthrapurpurin:

$$C_{14}H_5\left\{\begin{matrix}OH\\OH\\OH\end{matrix}\right\}O_2$$

When I became fully acquainted with this fact I was under the impression that an intermediate body must be formed, standing to anthrapurpurin as monoxanthraquinone does to alizarin, and formed simply by the replacement of the $SO_3H$ group in sulphoxanthraquinonic acid by HO.

Such a substance was found in artificial alizarin, and I have already described it; it is isoanthraflavic acid. In proof of its being always formed previously to anthrapurpurin, I succeeded in obtaining it directly by heating a salt of disulphanthraquinonic acid with a dilute solution of caustic potash. I employed a five per cent. solution of this alkali, and only little more than a sufficient amount to effect the decomposition indicated by theory, thus:

$$\underbrace{C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}O_2}_{\text{Disulphanthraquinonic acid.}}+6OKH=$$

$$\underbrace{C_{14}H_6\left\{\begin{matrix}OK\\OK\end{matrix}\right\}O_2}_{\text{Potassic isoanthraflavate.}}+2SO_3K_2+4OH_2$$

The mixture was heated in a closed iron vessel to 180–190° C. for six or seven hours. In this manner scarcely any anthrapurpurin was formed, and the alkaline solution, when acidified, gave a precipitate consisting chiefly of isoanthraflavic acid. So that in the formation of anthrapurpurin from disulphanthraquinonic acid we get the following changes: First, the formation of sulphoxanthraquinonic acid; second, the formation of isoanthraflavic acid; third, the formation of anthrapurpurin; and we see that isoanthraflavic acid is also an intermediate product in the formation of anthrapurpurin, and not a secondary one. The formation of anthraflavic acid has now to be accounted for. When sulphuric acid acts upon anthraquinone it is found to form two isomeric disulpho acids, one forming an easily soluble sodium salt, the other a less soluble one. The former is known as the $\beta$ sodic disulphanthraquinonate, the latter as the $\alpha$. This less soluble or $\alpha$ salt, when treated with alkalies, undergoes analogous changes to the $\beta$ salt, but, instead of forming isoanthraflavic acid, yields anthraflavic acid, and this, as previously stated, when heated strongly with alkalies, yields flavopurpurin. Anthraflavic acid is, therefore, an intermediate body and not a secondary one.

We see, then, how these various bodies are formed; and as they are proved to be intermediate products, their presence shows imperfection in the process of manufacturing, because, if perfect, these substances should not have been left, but have been converted into coloring matter. There are two other substances whose presence has not as yet been accounted for, and these are anthraquinone and hydroanthraquinone.

Monoxanthraquinone, isoanthraflavic acid, and anthraflavic acid, when being converted into coloring matter by treating with caustic alkali, cause nascent hydrogen to be liberated, as we have seen. This, acting upon other portions of these same substances, reduces them thus:

$$\underbrace{C_{14}H_8O_2}_{\text{Oxanthraquinone.}}+H_2=C_{14}H_{10}O_2+OH_2$$

$$\underbrace{C_{14}H_8O_4}_{\text{Isoanthraflavic and anthraflavic acid.}}+H_2=C_{14}H_{10}O_2+OH_2$$

And part of the anthraquinone thus formed also unites with hydrogen, forming hydroanthraquinone.

The presence of these two substances, then, represents a certain amount of reverse action, and, consequently, loss to the manufacturer. Fortunately means have been found of almost entirely preventing their formation, and also of insuring the intermediate products being converted into coloring matter. I shall have to speak of this further on.

I will now refer to the process of making artificial alizarin by means of dichloranthracene in place of anthraquinone.

Sulphuric acid forms two sulpho acids with dichloranthracene—a mono and a di.

To obtain the former, pure dichloranthracene is intimately mixed with concentrated sulphuric acid, warmed up to about 50° C., the mixture being well stirred; this process is continued for about twenty-four hours. It is then diluted, boiled, and filtered from any undissolved dichloranthracene. This filtrate gelatinizes on cooling, and consists chiefly of monosulphodichloranthracenic acid; it is formed thus:

$$C_{14}H_8Cl_2+SO_4H_2=\underbrace{C_{14}H_7(SO_3H)Cl_2}_{\text{Monosulphodichloranthracenic acid.}}+OH_2.$$

On boiling this with an oxidizing agent, it yields monosulphanthraquinonic acid:

$$C_{14}H_7(SO_3H)Cl_2+O_2=C_{14}H_7(SO_3H)O_2+Cl_2.$$

And this, when fused with caustic alkali, behaves in the same manner as the acid prepared from anthraquinone, yielding finally pure alizarin.

If the dichloranthracene be heated more strongly with sulphuric acid, it is converted into the disulphodichloranthracenic acid,* thus:

$$C_{14}H_8Cl_2+2SO_4H_2=$$
$$\underbrace{C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}Cl_2}_{\text{Disulphodichloranthracenic acid,}}+2OH_2$$

an acid remarkable for the fluorescence of its solutions and salts. If the heating with sulphuric acid be increased after the acid is formed, a very remarkable change takes place, sulphurous anhydride and hydrochloric acid being evolved in abundance, disulphanthraquinonic acid being at the same time formed:

$$C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}Cl_2+2SO_4H_2=$$
$$C_{14}H_6\left\{\begin{matrix}SO_3H\\SO_3H\end{matrix}\right\}O_2+2SO_3+2HCl$$

This, of course, when fused with alkali, eventually forms anthrapurpurin; and, as some of the disulphanthraquinonate is also formed, a little flavopurpurin is likewise produced.

There is also another reaction which takes place. As dichloranthracene combines with sulphuric acid, water is liberated, so that this acid becomes somewhat diluted. This does not readily form a sulpho acid with the dichloranthracene which has not dissolved, but when heated with it, converts it into anthraquinone:

$$\underbrace{C_{14}H_8Cl_2}_{\text{Dichloranthracene.}}+SO_4H_2=$$
$$\underbrace{C_{14}H_8O_2}_{\text{Anthraquinone.}}+2HCl+2SO_2$$

As the temperature rises the acid becomes concentrated, and then combines with it, forming chiefly monosulphanthraquinonic acid.

This process of making monosulphanthraquinonic acid from the monosulphodichloranthracenic acid has not been carried out successfully on the large scale, partly owing to the processes of filtration being very difficult to perform. But the preparation of artificial alizarin from the sulpho acids prepared by heating dichloranthracene strongly with sulphuric acid, is a process of very great importance.

As pure alizarin can now be obtained in any quantity, attention has been turned to the preparation of its derivatives. In 1874, I studied the action of bromine upon it, and obtained monobromalizarin, having the formula $C_{14}H_7BrO_4$.* This compound dyes mordants somewhat similarly to alizarin, the colors being a little redder in shade, but not sufficiently different to make it of technical interest. In 1875, I also obtained a nitro derivative of alizarin by acting on diacetoalizarin with fuming nitric acid.† This substance crystallizes in beautiful orange needles, and has the formula $C_{14}H_7(NO_2)O_4$. It produces with mordants colors very different from alizarin, giving with alumina brilliant orange, and with iron mordants reddish purple colors. It would be a valuable dyeing agent if it could be produced by a more easy process.

When treated with reducing agents, such as sodium amalgam, or metallic tin and potash, its blue alkaline solution changes to a clear bright red color, containing another new derivative, namely, amidoalizarin, $C_{14}H_7(NH_2)O_4$. This also dyes mordants, the alumina ones of a purple and the iron ones of a bluish or steel-like color.

A second, or $\beta$ nitroalizarin, isomeric with that I produced, has been obtained by Rosenstiehl,‡ and, apparently about the same time, by Caro,§ by submitting dry alizarin to the action of nitrous acid vapors. It is now manufactured in some quantities, and is known as alizarin orange. Like the nitroalizarin previously described, it gives orange colors with alumina mordants. They are, however, much yellower, and not so fine. This nitroalizarin dissolves in dilute alkalies with a purplish crimson color; but strong alkaline solutions precipitate it, especially caustic soda, and this property affords a means of purifying it. When boiled with metallic tin and caustic potash it is reduced, becoming blue and then yellowish green, but on exposure to the air this solution changes back to bluish green. Schunck and Roemer‖ have just published an account of this reduction product; it is an amidoalizarin isomeric with that just described. It crystallizes in deep yellow prismatic needles, and dissolves in potash with a blue color. It dyes alumina mordants a dull red, and iron mordants a dull gray color.

A very peculiar result has been obtained by M. Prud'homme¶ by heating a mixture of glycerine, $\beta$ nitroalizarin, and concentrated sulphuric acid. By this means a coloring matter is obtained which dyes alumina, and especially iron mordants, an indigo blue shade. It crystallizes in needles of an almost black color, but having a coppery reflection. The formula is $C_{17}H_9NO_4$. It is manufactured commercially, but as its colors are fugitive it has not met with much favor.

F. de Lalande** has made the interesting discovery that purpurin, identical with that found in madder, can be obtained by the oxidation of alizarin. He takes a solution of one part of alizarin in eight or ten parts sulphuric acid, and adds to it one part of arsenic acid or peroxide of manganese, and heats this mixture to a temperature of 150° to 160° C. until a drop of the fluid mixed with an alkali gives a red coloration. The product is then thrown into water, and the purpurin which precipitates is collected on a filter and well washed.

In this paper I have purposely confined my remarks to the coloring matters and other substances obtained in the manufacture of artificial alizarin, and also to some of the more important derivatives of alizarin; a considerable number of products have, however, been obtained, which are related to anthracene, although this hydrocarbon has not been used in their preparation, such, for example, as anthraflavone from oxybenzoic acid, etc. And, although I do not propose to give an account of these bodies, I wish briefly to refer to some very interesting results which have been obtained by Baeyer and Caro.

These chemists have observed that, when phenol is heated with phthalic acid or anhydride and an excess of sulphuric acid, two monoxanthraquinones are produced, one identical with that already described, the other being an isomeride of that body. Both of these, however, when fused with caustic alkali, yield alizarin.

By substituting pyrocatechin for phenol in the above process, they succeeded in obtaining alizarin at once. These results, although at present of no practical value, are of considerable scientific interest, and also show us that anthracene is not the only artificial source of alizarin.

From what I have told you this evening, you will see to what an advanced state the chemistry of my subject has arrived (and yet there is much to be done), and only those who have been interested in the progress of the manufacture can rightly appreciate the great value of all this research in forwarding the successful and economical production of these coloring matters.

As I have already shown, both of the important coloring matters of madder have now been obtained from anthracene, and not only so, but new products allied to these have also been produced, the most important one being that valuable coloring matter, anthrapurpurin; we have also flavopurpurin and the derivatives of alizarin. So that, with these color-

* *Deut. Chem. Ges. Ber.*, 1875, p. 1628, and 1876, p. 379.
† *Journal of the Chemical Society*, 1876, i., 851.
‡ *Deut. Chem. Ges. Ber.*, 1871, p. 106.
§ *Jahresbericht*, 1871, pp. 683, 684.

* *Journal of the Chemical Society*, 1874, p. 401.

* *Journal Chemical Society*, 1874, p. 401.
† *Journal of the Chemical Society*, 1876, vol. ii., p. 578, and *Deut. Chem. Ges. Ber.* 1875, p. 780.
‡ *Deut. Chem. Ges. Ber.* 1876, 1063.
§ Patent No. 1,229, March 22, 1876.
‖ *Deut. Chem. Ges. Ber.*, 1879, 588.
¶ *Bull. Soc. Chem.* (2), xxviii., 62-64.
** *Jahresbericht*, 1874, p. 486.

ing matters, dyers and calico printers are not only able to produce all the various madder styles, but to introduce colors of greater beauty and variety than when employing the natural dye-stuff madder.

*(To be continued.)*

## SELENIUM IN PLANTS.

DR. CHARLES A. CAMERON, of the Royal Dublin Society, appears to have measurably succeeded in causing plants to absorb and retain selenic acid without injury. His experiments were instituted for the purpose of ascertaining whether selenium, a substance analogous to sulphur, could not take the place of the latter in plant growth; but although the results answered his expectations to the extent stated, he did not feel warranted in saying positively whether there was a partial replacement of sulphur trioxide by selenium trioxide, or of sulphur by selenium. Other chemists have, from time to time, tried to substitute some of the elements found in vegetables by others of the same atomicity—for example, the compound ferric oxide by manganic oxide, and sodium for potassium, etc.—but unsuccessfully. Dr. Cameron found, many years ago, however, that rubidium could take the place of potassium, and he still seems inclined to believe that potassium may be replaced by sodium. The importance of this kind of research lies in this: If it is proved that plants can effect the replacement of an element not merely in an organic, but in an organized, body, an agency will be placed at the command of chemists, in the synthesis of new bodies, which cannot fail to produce valuable results.

## CHEMICAL ALTERATION OF IRON.

PROF. J. LAWRENCE SMITH, of Louisville, Ky., treated finely-divided cast-iron with ether and with petroleum. When the liquids evaporated he found needle-like crystals, consisting principally of sulphur, and exactly similar to those extracted by the same process from meteoric iron. He sent some of these crystals to Berthelot, who says that he had obtained like bodies by the action of pure ether upon octahedral sulphur and upon anhydrous iron sulphides. It thus appears that even neutral solvents do not in all cases act by simple solution upon the bodies with which they come in contact, but effect also a chemical alteration.

## NEW COMPOUNDS OF AMMONIA WITH HYDROCHLORIC ACID.

IN studying the vapor densities of ammonium compounds L. Troost has been led to the discovery of a number of curious compounds of ammonia with hydrochloric and other acids, both organic and inorganic. Two new compounds of ammonia and hydrochloric acid are described. To obtain them, ammonia gas, pure and perfectly dry, is saturated with pure hydrochloric acid gas. The ammonium chloride thus formed is distilled in a closed vessel in the presence of a large excess of ammonia gas, and the products cooled at varying temperatures. Two definite crystalline substances were obtained. The first has the formula, $HCl,4NH_3$, and is called by Troost tetra-ammonia chlorhydrate. It is anhydrous, and melts at $+7°$. Its crystals strongly depolarize light, and consequently do not belong to the same system as those of ordinary ammonium chlorhydrate. If the tension of ammonia given off by this substance be measured, it is found to remain constant for a given temperature, while the volume of gas existing at the surface of the dissociating substance is varied; just as the tension of water vapor, in presence of liquid water, remains constant for a given temperature with varying volume. This characteristic the author considers sufficient of itself to prove the definite existence of the substance described. Its tension of dissociation ranges from 140 mm. at $-36°$ to 1,800 mm. at $+8°$.

The second substance obtained has the formula $HCl,7NH_3$. It melts at $-18°$, but may be cooled to $-40°$ before solidification. The author was unable to distinguish its crystalline or optical properties from those of the preceding substance, but its appearance was quite different. The characteristics of its dissociation were the same as in the case of tetra-ammonia chlorhydrate, into which it is transformed by loss of ammonia. Its tension of dissociation ranges from 580 mm. at $-36°$ to 1,130 mm. at $-21°$. The author thinks that this is not the last term of this singular series. He was arrested at this point only by the difficulty of maintaining lower temperatures constant.—*Compt. Rend.*

## NOTE ON THE ABSORPTION SPECTRUM OF URANINE.

H. W. WILEY communicates to the *American Chemical Journal* the following:

Having only a small quantity of uranine, I took for the experiment ·0038 gramme. I dissolved this quantity in 500 c.c. of water and examined in a glass cell 13 mm. in diameter. ·0038 g. in 500 c. c. gave almost black band, the extreme edge of which is almost coincident with the F line of the solar spectrum. The absorption band extended from this point almost half way through the green. ·0038 g. in 1,000 c. c. gave a distinct band. ·0038 g. in 2,000 c. c. gave still a distinct band. ·0038 g in 4,000 c. c. gave a faint yet readily detected band. ·0038 g. in 8,000 c. c. gave no distinct absorption.

From the above it is seen that one part of uranine in one million parts of water is readily detected by its deportment in the spectrum. By increasing the thickness of the liquid traversed the delicacy of the reaction could be made more striking. I employed indirect sunlight for producing the spectrum, and Vogel's spectroscope in the observations. The examinations were made immediately after the solution of the substance.

AT the London Photographic Society, on May 13, Mr. W. G. Bird read a paper on the "Photographic Vision," showing from researches made by Kuhne and Boll, that a visual purple pigment exists in the eye, and that a theory is based upon this fact of a result similar to that which takes place in photography. A fixation takes place of an image in the eye by physical changes in certain minute rods and cones found in some membranes of the retina. The experiments appear to confirm the old theory that the eye of a deceased person or animal retains the last visual impression made upon it.

ACCORDING to the *Chemiker Zeitung* and the *Bergmann*, a Mr. J. Turnbridge has obtained thirty-four dollars worth of gold from a ton of the residues from the distillation of petroleum. The origin of the petroleum could not be ascertained.

[AMERICAN CHEMICAL JOURNAL.]

## PROGRESS OF INDUSTRIAL CHEMISTRY.

BRIEF REVIEW OF THE MOST IMPORTANT CHANGES IN THE INDUSTRIAL APPLICATIONS OF CHEMISTRY WITHIN THE LAST FEW YEARS.

By J. W. MALLET.

A THOUGHTFUL survey of the varying uses made by man of the forms of matter which surround him, and of the different methods by which he works these materials and fits them to his service, is always interesting. The ample and valuable reports upon the progress of industrial chemistry which appear nowadays at frequent intervals are not simply useful to the manufacturer engaged in each special branch of industry, but may be read with pleasure and profit by the student of scientific chemistry, who can look beyond the mere results of experience, and trace the history of principles side by side with that of their application; and by the well educated general reader, who may see spread before him one field, and that not a small one, of our expanding domain over external nature, the domain which constitutes our material civilization.

The very thoroughness, however, with which the best reports of this kind are prepared, makes it somewhat difficult to obtain from them a broad, general picture of the condition of chemical industry from time to time. One's attention is taken up and one's memory wearied by the multitude of details, a large proportion of which are of subordinate or temporary importance, while the transition from one great phase of a manufacture to another is thus rendered less noticeable; just as, when one becomes entangled in the movement of a great army, the impression of endlessly succeeding men and horses and individual commands makes it far from easy to obtain any general idea of the main direction taken or the changes in the positions taken up. It may, therefore, be worth while to attempt a short, condensed sketch of the principal changes which the last few years have brought about in the condition of the manufactures most dependent upon chemistry, overlooking the slow and often uncertain steps by which results have been reached, and the smaller details of improvement in the results themselves. Such a sketch must of necessity include matters for the most part familiar to all those whose attention has been given to this class of subjects, but need not on that account be without interest even for such.

It is not easy, nor is it necessary, to define with exactness what is meant by thus speaking of the "last few years." Different industries do not advance *pari passu*, and the position in which one is found at present may be essentially that which it assumed twenty or twenty-five years ago, while another may have undergone an important change within two or three or ten years, and a third may be now in the very act of transformation. It best answers the purpose aimed at to note for each the chief features of its present condition and most recent changes of importance. In some directions little or nothing is to be observed of really noteworthy progress, the history of a manufacture for a long time past involving either merely improvements in small though perhaps useful details, or attempts at new processes tried for a while and then allowed to pass out of use as unfit to replace older methods.

In such a general survey as is proposed, the salient points most attracting attention may be classified somewhat as follows:

I.—Improvements in the attainment of old results; depending on:
1. New sources of supply of long known materials.
2. Introduction of new materials.
3. New processes involving either new principles or modifications in the application of old ones.
4. New mechanical appliances.

II.—Attainment of new results arising from:
1. New means of production.
2. New demands from consumers.

III.—Disposition made of:
1. Old and
2. New secondary products or waste materials.

IV.—New and special conditions of work, as:
1. Changes in labor market.
2. Changes in legislation, taxation, tariffs, etc.
3. Exceptional demands for particular products, as under stress of war, blockade, etc.

V.—Problems:
1. Long outstanding.
2. Recently suggesting themselves, which still await solution.

As regards the several departments of industry which may be claimed as chemical, or closely related to chemistry, they will be run over pretty nearly in the order in which the writer has been in the habit of discussing them in annual lectures to one of his classes of students.

### FUEL, AND ARRANGEMENTS FOR THE ARTIFICIAL PRODUCTION OF HEAT.

Under this head we may fairly place foremost in importance among still recent improvements the admirable gas furnace of Siemens. The invention, in its practical shape, involves two distinct ideas. First, the production by simple, readily controlled means, and from cheap, even refuse forms of combustible matter of a purely gaseous fuel, the supply of which to the furnace can be regulated as easily as by turning a stop-cock, while all injury to the material heated arising from soot, ashes, and unburnt particles of solid fuel is completely obviated; secondly, the arrangement of a hearth in which this gas may be burned in admixture with air after both have been separately raised to a high temperature by passage through heated chambers filled with loosely piled fire-brick, while the heating of a second pair of such chambers, through which the gas and air may be turned after the others have cooled down, is accomplished by leading through them on the way to the chimney the products of combustion from the other end of the hearth. By shifting the dampers or valves at intervals the air and gas supply is transferred from one end of the hearth to the other, one pair of fire-brick chambers being always engaged in storing up heat which otherwise would go to waste with the draught up the chimney, while from the other pair such accumulated heat is taken up by the gaseous fuel and air on their way to the hearth. In fact, we have here essentially the principles of the "oxyhydrogen blow-pipe" and the "hot blast" combined and applied in simple form and upon a grand scale. As to the temperature so producible, it may be said that its practical limit is found in the difficulty of getting material infusible enough for the hearth lining, while the actual temperature at which the furnace is worked may be regulated by simply turning on or off the valves which control the admission of gas and air, and with a precision far beyond that which depends upon any mechanical stoking of solid fuel. And, most difficult object of all to attain with any of the older forms of furnace, and of great importance often from the chemical point of view—the *relative* supplies of combustible gas and air may be easily so adjusted by using the respective valves independently as to yield in the hearth an oxidizing, a reducing, or a pefectly neutral atmosphere.

Whether in connection with the "regenerator" gas furnace or the old-fashioned reverberatory, a most useful labor-saving appliance of comparatively recent years is the rotating hearth, a cylindrical or barrel-shaped vessel of iron lined with infusible material which is slowly revolved about its axis of figure by gearing on the outside, while through it from end to end passes the flame on its way to the chimney; the material to be heated being turned over and over, its different parts mixed, and fresh surfaces exposed to the flame, without the necessity for severe manual labor on the part of workmen with iron bars, and without the exposure to air which the introduction of these bars entails.

The simplicity and economy with which combustible material, otherwise of small value, may be converted into gaseous fuel in the "generator" of Siemens' invention, and the advantages which attend the use of fuel in this form, apart from its employment in his furnaces, suggest a probably much wider field for its use in the future in connection with various branches of chemical manufacture. "Water gas," essentially a mixture in various proportions of hydrogen, carbon monoxide, carbon dioxide, and atmospheric nitrogen, obtained by bringing water in contact with glowing carbon, whose combustion is properly regulated, seems to have first been distinctly noticed in Fontana in 1780, and has repeatedly since then attracted attention, but no arrangement for its ready production at will has combined so many practical advantages as the Siemens generator.

To some extent the immense natural supplies of combustible gas—chiefly methane and ethane—obtainable in portions of the petroleum region of Pennsylvania, Ohio, and West Virginia, have been utilized as fuel, but the merely local character of such supply must always very much limit its importance.

The great loss of heat, amounting to about two-thirds of that producible from the fuel used, which is involved in allowing the formation in a furnace of carbon monoxide, and its escape unburned or burned only to waste,* has come to be pretty generally understood; and especially from blast furnaces used in making pig iron, is this gas now very commonly collected by means of suitable flues from the upper part of the furnace, and made use of not only for purposes connected with the working of the furnace itself, as raising steam for the engine and heating the blast, but occasionally as the means of producing heat for other objects, as burning lime, bricks, common pottery, etc. The time is not far back when this portion of the fuel was almost always wasted.

For certain purposes, though not most prominently for chemical manufactures, the use of liquid fuel claims serious attention; but the most valuable material of this kind which we possess, crude petroleum, distinguished by its great heat-producing power, its abundance and cheapness, still awaits a satisfactory solution of the problem of its application.

When lower temperatures than those directly resulting from combustion are required, steam becomes invaluable as the means of transmitting, distributing, and regulating the supply of heat, and both at the boiling point and superheated, both at ordinary and high pressure, it plays a more and more important part in the arrangement of chemical factories, the water resulting from its condensation being at pleasure allowed to mingle with or excluded from the material heated, while the escape of steam itself is sometimes available as the means of producing mechanical agitation.

### SLAG WOOL.

It may not be unworthy of mention that the "slag wool" now produced upon a fairly large scale by blowing a jet of steam or air forcibly over the surface of furnace slag in a state of fusion, affords an excellent material for jacketing boilers, steam pipes, hot-air flues, etc., in order to greatly diminish, by its low conducting power, the loss of heat in transmission, while danger from fire and annoyance from rotting or moulding of organic substances are obviated by the unalterable character of this mineral material.

### METALLURGY—IRON.

The grand fact in the history of iron for the last twenty years has been the gradual but pretty rapid substitution of the softer varieties of steel to a very large extent for wrought iron. The earlier experiments of Bessemer and some others who worked at about the same time, were directed to the production of this latter material by a quicker and easier process than "puddling" for the removal of the carbon of cast iron. These experiments were unsuccessful so far as the complete removal of carbon and production of thoroughly soft, pure iron was concerned; but they proved the feasibility of manufacturing steel directly from cast iron with far less expenditure of time, fuel, and labor than older methods, such as "cementation," involved, in which carbon had first to be removed, producing wrought iron, and subsequently added again slowly and in restricted amount. The new processes, moreover, carried with them the great advantage of operation at so high a temperature that the metal was completely fused, and hence much more uniform in character than when masses were consolidated by welding only from parts varying in the amount of carbon, and hence in physical properties, and retaining also in the case of bar iron more or less remains of slag. It did not take long to show that these characteristically new processes were not destined to replace the older ones for the manufacture of wrought iron, properly so called, but it was not so quickly perceived that neither were they fitted for the production of the best steel, of such kinds as the name had previously been most largely applied to. Gradually it became apparent that the true function of the newly invented methods was mainly the production of a new material, containing carbon in relatively small amount, combining the toughness and workable qualities of wrought iron with the great tensile strength, rigidity, some of the hardness, and especially the homogeneity due to practicable fusibility of steel. The "mild steel," which is the essential result of the recent processes of manufacture, is not the "tool steel" which not many years ago was pictured in every one's mind in connection with the name steel, but it is a substance available for a far wider range of uses and applicable upon a far greater scale.

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* C burned to $CO_2$ evolves 96·960 heat units (obtained by complete combustion).
CO " " $CO_2$ " 67·284 " " (lost by escape of CO).
C escaping as CO " 29·676 " "

### STEEL.

Of the various individual processes which have been proposed and tried for the rapid production of mild steel, decidedly the most successful have been those of Bessemer and Siemens; the former consisting essentially in forcing a blast of air under high pressure into molton cast iron in a suitable "converting vessel," thus rapidly burning out the carbon and silicon, mixing with the fluid metal a determined amount of separately fused cast iron containing a known amount of carbon, and casting the product into ingot moulds; while the latter brings into play the admirable peculiarities of the gas furnace by fusing together at the extremely high temperature which it affords, and in the entirely controllable chemical atmosphere of its hearth, pig iron and scrap wrought iron, as suggested by Martin, or pig iron and iron ore (an oxide) on the plan of Uchatius, but on a much greater scale in either case, so apportioning the carbon and iron left together in the fused product that steel of the required character shall be obtained. In a sense it may be said that the invention of Siemens, leading to the manufacture of "Siemens-Martin" and "Landon-Siemens" steel, has supplemented the Bessemer converter, and by providing a way for profitably using up vast stores of old wrought iron already on hand, has permitted the more rapid substitution of steel manufactured by both methods. By these two processes, within the last two or three years an annual product of more than 2,500,000 tons for the world at large has been turned out.

During the period in which so much attention has been concentrated upon steel much has been learned in reference to the effect in its production and upon its properties of even very small quantities of other elements than iron, though much still remains to be ascertained in this direction.* The most important points which have been ascertained are those in regard to the benefit derivable in the manufacture, particularly of Bessemer steel, from the presence in the iron of manganese and silicon; the chief function of the former being the removal, to some extent, of sulphur, phosphorus, and oxygen, which, if allowed to remain, greatly impair the mechanical excellence of the product, while they exhibit a stronger tendency to combine with manganese than with iron, and thus get carried off into the slag; silicon, on the other hand, aiding by its combustion to keep up the high temperature in the converter which maintains the fluidity of the metal, and uniting when burned with the basic oxides to form and separate from the metal a removable form of fluid slag. The observed benefit arising from the presence of these two substances has stimulated the production, for use in connection with steel making, of cast iron rich in silicon, of crystalline "spiegeleisen," containing a large and uniform amount of carbon along with manganese, and lately of alloys of iron and manganese—the so-called ferro-manganese—containing, as in the product of the French Terre-Noire works, up to 65, and even 85, per cent. of the latter metal. Another point, and of unexpected character, has but lately been ascertained—namely, that if the percentage of carbon in steel be reduced, phosphorus may be admitted to an extent which would be seriously injurious if the normal amount of carbon for the kind of steel required had been present. Some remarkable specimens of steel from works on the Siemens-Martin plan, in New Jersey, in the possession of the writer, illustrate this distinctly. Notwithstanding the numerous attempts, too often reported on by interested parties, to produce valuable alloyed forms of iron or steel by addition of other metals, most of which attempts have led to no permanent results of real importance, it remains much to be desired that a systematic examination should be made by impartial hands of the alloys of iron, with and without the presence of carbon, trustworthy analyses being made of the products, and at the same time their physical characters submitted to well-defined tests. Up to this time the only two of the more refractory metals which seem to have proved themselves capable of influencing in any useful way the properties of steel are tungsten and chromium, which give hardness, accompanied, however, by increased brittleness.

The increase of retentive capacity for magnetism which tungsten is reported as producing may perhaps prove valuable in the construction of dynamo-electric machines.

### WROUGHT IRON.

As regards wrought iron, whose day for many purposes can by no means be considered as gone by, the most notable manufacturing improvement has undoubtedly been the introduction of mechanical puddling as a substitute for the more laborious and less uniform hand-work. After many previous attempts success in this direction has come with the application of the rotating hearth, of which the Danks furnace arrangement deserves to be taken as the type. The more general use of currents of water through double furnace walls as the means of allowing the highest temperatures within, with diminished risk of injury to the walls themselves, is an extension of the long-used water backs of the refinery furnace.

### CAST IRON.

For cast iron, aside from the marked increase in the size of many of the furnaces built, and in some hands the use of a blast of considerably higher temperature than was usual a few years ago, the question of most interest has been that of the elimination from the metal of phosphorus and sulphur, particularly the former, with a view to the supply of metal to the steel makers suited in this respect to their requirements, since the modern methods of steel manufacture do not tend to remove phosphorus if present, the Bessemer process even relatively increasing its amount, and its retention in the steel to any large extent being ordinarily in the highest degree objectionable. The comparative scarcity and therefore cost of ores originally free, or nearly so, from phosphorus, while others are abundant against which the presence of this element can alone be urged in objection, renders the problem one of great importance.† Of the many plans proposed for getting rid of the undesirable element, two seem most to deserve notice. It has been found that in Cleveland ironstone from Yorkshire, in England, and the same is probably true of many other ores, the phosphorus exists mainly, if not solely, as calcium phosphate, and that by washing the ore with a solution of sulphurous acid, obtained by passing the sulphur dioxide from burning pyrites into water, a large proportion, up to even 90 per cent. of the phosphorus, may be dissolved out and removed. It has been urged against this process as a fatal objection that the ore must be in fine powder to allow sufficiently thorough contact with the liquid acid, while the pulverulent condition unfits it for smelting in the ordinary way. While this is true as regards after use in the blast furnace, it seems quite possible that ore in powder might be managed in the Siemens furnace for the production of "Landon" steel, and, in the absence of material naturally pure enough, this process of preparatory washing may yet find application to a certain extent. The other plan to be mentioned has more extensive claims to attention, if the facts upon which it rests are fully confirmed by further experience, and if it can be brought into practically workable shape. Mr. Lowthian Bell, to whose intelligently directed researches we owe much important information in regard to the chemistry of iron smelting, believes he has ascertained that phosphorus may be in large measure removed from melted cast iron by oxidation at a temperature lower than that suited for puddling, the oxygen being derived from a bath of molten oxide of iron or slag very rich in such oxide; though at a higher temperature, at all approaching that of the Bessemer converter, phosphorus would be taken up again by the iron from the very same slag. It is proposed that the iron shall be brought rapidly into contact with the rich slag by running it from the furnace into a circular converting vessel revolving about its axis and containing the slag already in a state of fusion. In one experiment it was found that the phosphorus in iron from Cleveland ore could by such treatment be brought down to ·055 per cent., while continued contact, at full puddling heat, with the puddling furnace slag which had served as the means of purification, raised the proportion of phosphorus again to ·153 per cent. in 65 minutes, and to ·365 per cent. in three hours. These experiments are suggestive and full of promise that a solution of this important problem will yet be found, though as yet it cannot be said to have been reached in a practically useful and generally applicable form.

### REMARKABLE APPLIANCES.

In noting the chemical aspects of the iron and steel industry, as developed in the last quarter of a century, we cannot overlook the magnificent scale upon which the mechanical appliances used in working the metal have outgrown their former dimensions.

A visit to such works as those of Creuzot in France, Krupp's establishment at Essen, in Germany, the heavy gun factories at Chatham, and the armor-plate mills at Sheffield, in England, or even to several of the works which have grown up in this country, presents a truly impressive picture of mechanical power directed and controlled by human brains. Such a single tool as the great Creuzot steam hammer, with its 75 or 80 tons of iron falling 18 feet upon an anvil of nearly 900 tons, and capable of forging masses of steel of 120 tons or more, represents a marvelous advance upon the means at the command of the iron workers of fifty or even twenty years ago. Yet the very source of the demand for these mighty machine tools, the growth of the manufacture of iron, and yet more steel, has in the improved character of the material produced opened up a still wider field and enlarged possibilities for the employment of mechanical energy upon the grandest scale.

*(To be continued.)*

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* An important paper by V. Deshayes has recently been published (Bull. de la Soc. Chim. de Paris, 20 Fév. and 5 Mars, 1879), giving the results of an extensive examination of the influence upon the physical properties of steel of its various minor constituents—phosphorus, silicon, manganese, etc.

† It seems possible that one of the main features of Heaton's process for making steel from cast iron rich in phosphorus—viz., oxidation by sodium nitrate at the bottom of a converting vessel—may be revived in perhaps a more permanently successful form. M. Gruner asserts of late (Bull. de la Soc. d'Encourag. pour l'Indust. Nation., Jan., 1879) that phosphorus may be removed in either the Bessemer converter or the Siemens furnace if a refractory *basic* lining be substituted for one of silicious materia..

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## PHOSPHORESCENCE.

FOR the last two years the public has become more or less familiar with a pretty device for foretelling the state of the weather, and consisting of artificial flowers impregnated with certain chemicals that gave them hygrometric properties. These we have already described in a preceding volume. For a few months past there has been exposed for sale in the shops another novelty, in the form of artificial flowers, so prepared as to be phosphorescent in darkness, after having been exposed to the rays of the sun, the electric light, or incandescent magnesium.

FIG. 1.—ARTIFICIAL FLOWER COVERED WITH A PHOSPHORESCENT POWDER, EXPOSED TO THE LIGHT OF A BURNING MAGNESIUM WIRE.

There are some very interesting and very curious phenomena connected with such objects as the latter, and some that are not generally known; and to these we wish to call the attention of our readers.

The property possessed by certain bodies of emitting light when placed under certain conditions is much more general than commonly supposed. M. Edmond Becquerel, to whom we are indebted for a remarkable work on this subject, divides the phenomena of phosphorescence into five distinct classes:

1. *Phosphorescence by elevation of temperature.*—Among the substances that exhibit this phenomena to a high degree, may be mentioned certain diamonds, the colored varieties of calcium fluoride, certain other minerals whose base is lime, and the sulphides known under the name of artificial phosphors, when they have been previously exposed to the action of light. Sulphate of quinine, too, when heated to about 212°, becomes luminous, especially when rubbed.

2. *Phosphorescence by mechanical effects*, such as friction, percussion, cleavage, etc.; for example, when two crystals of quartz are rubbed against each other in darkness, or when a lump of sugar is broken.

3. *Phosphorescence by electricity*, like that which results from the friction of mercury against the glass in a barometric tube, and especially from the electric sparks proceeding either from an ordinary electrical machine or from a Ruhmkorff's coil.

FIG. 2.—THE SAME FLOWER EMITTING LIGHT IN DARKNESS.

4. *Spontaneous phosphorescence.*—This is observed in certain animals and plants. For instance, it is very intense in the glowworm and cucujo, and the brightness of their light seems to be dependent on their will. In tropical climates the sea is often covered with a bright phosphorescent light due to *noctilucæ*—minute zoophytes. These animalcula emit a luminous matter so subtle that, MM. Quoy and Guimard, during a voyage under the equator, having placed two of the animals in a tumbler of water, the liquid immediately became luminous throughout its entire mass. Phosphorescent effects are also produced in organic substances, animal or vegetable, before putrefaction sets in; and they are also exhibited at the time of flowering of certain plants, etc.

5. *Phosphorescence by insolation, or exposure to the sun.*—A large number of substances, after having been exposed to the action of sunlight or of the diffused light of the atmosphere, emit in darkness a phosphorescence, the color and intensity of which depend on the nature and physical condition of these substances. It is this kind of phosphorescence which has been studied by M. Becquerel.

These phenomena appear to have been first observed in precious stones, then in "Bolognese phosphorus" (sulphide of barium), in 1604, afterward in the diamond, by Boyle, in 1663, then in "Baudoin phosphorus" (the residue from calcination of calcium nitrate), in 1675, and in more recent times in a very large number of substances.

The sulphides of calcium ("Canton phosphorus"), barium ("Bolognese phosphorus"), and strontium are those which exhibit the phenomenon in the highest degree. When well prepared, after being exposed to the light, they are luminous for several hours in darkness. But as this phosphorescence takes place in vacuo, as well as in a gaseous medium, it cannot be attributed to a chemical action, but rather to a temporary modification which the body undergoes from the action of light. After the foregoing substances the best phosphorescents are the following, in the order in which they are named: A large number of diamonds (especially yellow), and most specimens of fluorspar, then arragonite, calcareous concretions, chalk, apatite, heavy spar, dried nitrate of calcium, dried chloride of calcium, cyanide of calcium, a large number of strontium and barium compounds, magnesium and its carbonate, etc. Besides these, a large number of organic substances also become phosphorescent by insolation; for instance, dry paper, silk, cane sugar, milk sugar, amber, the teeth, etc.

Phosphorescent sulphide of calcium (Canton phosphorus) is prepared by calcining a mixture of flowers of sulphur and carbonate of lime in a crucible. But the preparation only succeeds when carbonate of lime of a particular kind is employed. That derived from the calcination of oyster shells gives very good results. Three parts of this substance are mixed with one part of flowers of sulphur, and heated to redness in a crucible, luted to prevent access of air. Canton phosphorus thus obtained gives in darkness a yellow light, after insolation. The calcareous matter of oyster shells is not always pure, and the result obtained is sometimes not very satisfactory; for this reason it is better to use a material the composition of which has been well determined.

When it is desired to prepare a phosphorescent sulphide with lime or its carbonate, says M. Becquerel, the most suitable preparations to use are, in 100 parts of the material, 80 per cent. of flowers of sulphur in the first case and 48 per cent. in the second; in other words, such a quantity of sulphur as would be necessary to be burned by the oxygen of

the lime or its carbonate in order to form a monosulphide. During the preparation care must be taken in regard to the elevation of temperature as well as to its duration. In operating with lime derived from fibrous arragonite, and keeping the crucible up to a temperature a little less than 500 degrees for a sufficient length of time to allow a reaction between the sulphur and lime to take place and the excess of sulphur to be eliminated, a mass is obtained which is slightly luminous, with a bluish tint; but if this mass be heated up to a temperature of 800 to 900 degrees, and does not go beyond the melting point of silver or gold, the phosphorescence that it exhibits is very bright.

Sulphide of calcium enjoys phosphorescent properties which vary according to the nature of the salt that has served to produce the carbonate of lime employed in its manufacture. If marble be converted into nitrate of lime by dissolving it in diluted nitric acid, and the salt be precipitated by carbonate of ammonia, and the carbonate of lime thus obtained be used in the preparation of the sulphide of calcium, we have a product which gives a phosphorescence of a pinkish-violet color. If the carbonate of lime made use of be derived from chloride of calcium, precipitated by carbonate of ammonia, the phosphorescence is yellow. By treating with sulphur, carbonate of lime prepared by passing carbonic acid gas through lime water, a sulphide is obtained, the phosphorescent light of which is of a very pure violet. Carbonate of lime derived from the precipitation of commercial crystallized chloride of calcium by different alkaline carbonates, also gives very good results.

Luminous sulphides of strontium may be obtained, like those of calcium, by the action of sulphur on strontia or the carbonate of this base, and by the reduction of sulphate of strontia with carbon. In these compounds green and blue shades predominate.

The sulphides of barium likewise exhibit very remarkable phenomena of phosphorescence. However, in order to obtain very luminous masses, a higher and longer sustained temperature than that for the other compounds is generally necessary. In the barium preparations the phosphorescent tints vary from orange-red to green.

The preparation of the substances just enumerated allows of an easy explanation as to how the luminous flowers are manufactured that we spoke of in the beginning of this article. The proper artificial flowers having been selected, are brushed over with some liquid glue or other, mucilage for instance; then they are dusted over with a phosphorescent sulphide and dried. The powder thus becomes firmly attached to them. It is only necessary to expose a flower thus prepared to solar light, or to the rays emanating from a burning magnesium wire, to make it phosphorescent. (Fig. 1.) If it be then taken into a dark room (Fig. 2) it shines with a bright light, and emits colored rays that have a charming effect. The luminous effect is increased by heat; and it is well, therefore, to slightly warm the flower before trying the experiment. Phosphorescent sulphides are sometimes used for making drawings, or writing on paper, etc., and, as may be seen, these experiments can be infinitely varied at the will of the experimenter.

But the question arises, cannot these substances be put to more serious uses, and is there no reason to hope that they may be eventually classed among useful products? It would seem to us that the answer should be in the affirmative. Luminous clock and watch dials are already being made from these phosphorescent materials, and it would not be impossible to use them in making signs for shops and numbers for houses which could be read at night. Prof. Morton, it will be remembered, goes still further (SCIENTIFIC AMERICAN, April 12, p. 232), and proposes not only to cover the walls of rooms with these substances, but also the fronts of houses, so that street lamps might be done away with.

## MATERIAL FOR STANDARD WEIGHTS AND MEASURES.

FRIED. MOHR suggests that a block of uncrystalline black marble be used for the standard meter. The block should have the dimensions: 111 cm. in length; 20 cm. in height and breadth; *i. e.*, it should be a parallelopipedon of 44,000 c. c. The specific gravity being 2·7, the weight of the block would be 118·8 kilogrammes, or nearly 3½ cwt. These dimensions afford sufficient protection against: 1, breaking; 2, distortion; 3, sudden action of heat; 4, theft; and further, they admit of the possibility of determining the temperature of the block exactly, as a thermometer can be sunk into a hole reaching to the middle of the block. The coefficient of expansion of black marble is 0·0000045 for 1° C. As the meter has 1,000 mm., $\frac{1}{1000}$ mm. = 1 millionth part of a meter; 4·5 thousandths of a millimeter = $\frac{1}{222}$ mm., a distance which cannot be seen without the microscope.

The author considers rock crystal the best material for weights, but as such weights would necessarily be very dear, he suggests the use of solid glass containing a large proportion of silicic acid. The conditions to be satisfied are: 1st. That all the weights should be made from materials of the same density; 2d. That the specific gravity of the pieces used should approach nearly to that of the substances commonly weighed; and 3d. That the weights should have a certain hardness to protect them from wear.—*Annalen der Chemie.*

## NITROUS OXIDE AS AN ANÆSTHETIC AGENT.

P. BERT has made some experiments on animals which indicate the possibility of employing nitrous oxide as an anæsthetic agent in the cases of operations requiring considerable time. The use of the gas is dangerous because it must be inhaled in pure condition, and hence suffocation soon follows in consequence of a lack of oxygen. The fact that the gas must be inhaled in pure condition signifies simply that its tension must be equal to one atmosphere in order that enough shall enter into the system. If, however, the patient is placed in an apparatus in which the pressure is increased to two atmospheres, then a mixture of 50 per cent. nitrous oxide and 50 per cent. air may be employed. The anæsthesia will be effected, while at the same time the normal quantity of oxygen finds its way into the blood, and normal conditions of respiration are preserved. The author's experiments on animals showed the correctness of the above reasoning. Unconsciousness was reached while normal respiration continued, and this condition could be maintained for an hour. On removing the bag which contained the mixture of gas the animal returned to its normal condition after two or three inhalations of fresh air. During the action of the anæsthetic, the animal showed no signs of pain, even when nerves laid bare for the purpose were subjected to pressure, or when its limbs were amputated. No bad after effects were observed.—*Comptes Rendus.*

## PURIFICATION OF MERCURY.

J. W. BRUEHL recommends the use of chromic acid for the purification of mercury. Twenty-five kilogrammes of mercury, which contained a considerable quantity of Wood's metal, were perfectly freed from the foreign substance in about two hours. To one liter water are added five gr. potassium bichromate and a few cubic centimeters sulphuric acid, and an equal volume of mercury is well shaken with this mixture. The metal breaks up into globules, while a very small quantity is transformed temporarily into red chromate. The flask is shaken until the red powder has disappeared, and the aqueous solution becomes pure green from the chromium sulphate formed. A strong current of water is now passed into the flask, and a fine gray powder which lies upon the surface of the mercury and between the globules, and consists of the oxides of the metals, is thus washed away. According to the degree of impurity this process is repeated once or twice more, and finally the whole is shaken with distilled water until no more gray powder is washed away, and the water remains perfectly clear.

This method was tested with a large quantity of waste mercury that had accumulated in the author's laboratory in consequence of the amalgamation of the zinc plates of a battery. Much of this mercury contained so much zinc, copper, and lead that it was solid. In the course of an afternoon it was purified so completely that when shaken in a porcelain dish it did not leave a trace of a mark upon the porcelain.—*Ber. Deutsch. Chem. Gesell.*

## STRENGTHENING ALCOHOL.

STRONG alcohol is a *sine qua non* to the photographer, whether he be a bath plate or emulsion worker; for, in the former process, strong alcohol must be employed for the manufacture of the collodion, and in the latter it is even still more necessary for redissolving the pellicle after it has been washed and dried. For this purpose alcohol of a higher specific gravity than ·805 to ·815 should not be used, and the greater density is only admissible when the pellicle has been most thoroughly desiccated, otherwise there is a danger of the film proving crapy when it is dry.

Spirit of a suitable strength may be obtained without difficulty in most large towns, but not so in many country places. Formerly methylated alcohol of a suitable strength could also be had at most operative chemists, and for many purposes it answered quite as well as the more expensive kind; but the sale of this article, of a greater strength than that obtained by ordinary distillation, is now prohibited by law, so also is the employment of any means for strengthening it. We lately stated that alcohol of a greater strength than ·825 or ·820 could not be obtained by simple distillation, therefore some chemical means must be employed to strengthen it or deprive it of water. The means generally adopted to accomplish this is the addition of some material having a greater affinity for water than the alcohol possesses, such as quick-lime, carbonate of potash, chloride of calcium, etc.—and then distilling it. The water of the spirit combines with the body added, and the real alcohol distills over.

We wish here to describe the method by which this article may be raised to the requisite strength from the ordinary commercial spirit of wine, which may be obtained from most chemists. If the highest degree of concentration be desired proceed in the following manner: Put (say) a quart of spirit of wine into a Winchester quart bottle, add to it some well-dried carbonate of potash (salt of tartar) and allow it to remain a day or two, shaking the bottle occasionally. The potash will combine with the water and sink to the bottom as a dense, oily-looking liquid. About four ounces will be required if the spirit be of the average strength and the salt thoroughly dry. Now decant the alcohol from the solution of potash into another bottle, and add a pound and a quarter of freshly-burnt quick-lime in powder; allow it to digest for a day or two, in the same manner as it did with the potash, then transfer the whole to a still, placed in a water bath, and distill at a temperature not exceeding 200°.

By following these directions alcohol of a strength of ·805 to ·800, or even stronger, may be obtained. In place of the lime chloride of calcium may be employed. If a strength of ·815 to ·810 only be required, then the following plan may be adopted: Put the spirit in a bottle and add carbonate of potash as previously directed, and after digesting for twenty-four hours decant into a dry bottle, add a fresh supply of potash, and again digest. If the salt remain quite dry at the bottom of the bottle the spirit is ready for the still; but if it become wet the operation must be repeated. In place of a still—the use of which requires a license from the excise—a retort fitted with a Liebig's condenser may be used

These operations are exceedingly simple, and the only precautions to be taken are to see that the vapor of the alcohol does not escape and come in contact with a flame, by which it would be ignited, and also that the hygroscopic material, whatever it may be, is thoroughly dry. The best plan to insure perfect dryness is to place it in an open vessel (an iron saucepan answers well) over the fire until it becomes well heated, stirring it the while, and then adding it to the alcohol—in fact, quenching it in the spirit—observing, of course, that it is not hot enough to fire it.

As many may object to re-distilling, we give one or two plans of strengthening spirit that do not require that operation, and yet with proper care will yield fairly good results. It is the water absorbent that really strengthens the spirit, and the only object of distilling is to separate the spirit from it after it has done its work. From this it will be seen that if the material added be insoluble in alcohol the operation of re-drawing is unnecessary. Carbonate of potash is quite insoluble in alcohol, but, as is generally the case, it is contaminated with caustic potash; the alcohol will be rendered alkaline by reason of the solubility of that salt in it. Chloride of calcium and most other agents employed to abstract water are also soluble; hence the necessity of redrawing. Carbonate of potash may, however, be obtained quite pure (then distillation is unnecessary); but it is somewhat expensive compared with the commercial article. We have frequently seen it stated that if dry shred gelatine be placed in weak alcohol it will absorb the water from it. This is a fallacy, as can be proved by digesting some in alcohol of (say) 60° o.p., when it will be found at the end of several days to be quite as crisp as at first; though if, for experiment, the alcohol be diluted to sp. gr. ·900, the gelatine will, after soaking a day or two, become limp and swell up, but the alcohol will prove upon testing to be of the same strength as it was at first, thus showing that the gelatine has no greater affinity for the water than the spirit has.

A curious and, at the same time, efficacious mode of strengthening alcohol is founded on the fact that alcohol does not moisten animal tissues. Hence, if an ox bladder be filled with spirit of a sp. gr. ·830 and suspended for a few days in a warm room or in the sun, the spirit will be found to have its specific gravity reduced to ·805, or even ·800. The theory of the operation is that the water permeates the bladder and evaporates from the outer side, but as the alcohol does not moisten the bladder it cannot get through, and consequently remains behind free from water. The same bladder will serve for dozens of operations; but the first one or two lots of spirits treated will be somewhat impure by reason of its dissolving a little fatty matter from the membrane, which it is impossible to remove by simple cleansing.—*British Journal of Photography.*

## THE SUPPLY OF NITROGEN.

By W. D. PHILBRICK.

THIS topic is naturally suggested by the war in South America, which threatens to disturb for a time the trade both in Peruvian guano and nitrate of soda. Whether the disturbance is likely to be serious or long continued is a question for the students of South American history to discuss; my present purpose is only to call attention to the very great importance of the articles in question to the civilized world, and especially to the highly cultivated portions of England and America. So thoroughly is England impressed with this idea that she has already dispatched an armed fleet to protect British interests in those parts.

One would naturally think that a substance which forms four-fifths of the air we breathe, and which composes an essential ingredient of all nutritious food, of our bodies, of all animal and most vegetable substances, would hardly need to be sought for in the remote regions of the globe, and would hardly command a price of twenty to twenty-five cents per pound in the chief markets of the world. Such, however, are the facts with regard to nitrogen.

The nitrogen of the air is indeed free as air, but the nitrogen of nitrate of soda, of sulphate of ammonia, and of many other substances, is worth the price above named. Whether the nitrogen contained in manure, in waste fish scrap, and many other sorts of refuse matter, is as valuable for agricultural purposes is an open question, the answer depending in great measure on the kind of crop for which it is required; thus, for seeding down grass land or for application to asparagus fields or orchards, where lasting effect is desired without regard to interest on the outlay, the slowly available forms of nitrogen (as manure, raw bones, or fish waste) would probably be economical, as they sell at low figures. But the market gardener or farmer who wishes immediate returns would often prefer to pay the price for the quicker acting salts of ammonia or nitric acid.

In this connection it may be interesting to state some of the chief sources of nitrogen. Nitrate of soda or Chili saltpeter is imported from Chili, where it is found pervading the soil of that rainless country and incrusting the surface so as to make it look white. The earth is simply washed with water, and the solution evaporated and crystallized. It is found in commerce of very uniform quality, being about ninety-five per cent. pure, the balance being water and common salt; the pure salt contains seventeen per cent. of nitrogen. It is used largely in the preparation of sulphuric and nitric acids at the chemical works, being cheaper than nitrate of potash, and is often used in the manufacture of nitrate of potash, when prices will warrant the operation. The nitrate of soda, however, is not much used for making gunpowder, as it readily absorbs moisture from the air. It sells at 3½ to 4½ cents per pound.

Sulphate of Ammonia.—This salt is obtained chiefly as a secondary product, in the manufacture of illuminating gas, the dark, stinking water which is deposited in gas-house condensers containing a considerable percentage of ammonia. This tar water is usually boiled until the ammonia is all driven off, the vapor being carried into a vat of sulphuric acid; the product is the crude, gray sulphate of ammonia of commerce, usually nearly pure, and containing, when pure, twenty-two per cent. of nitrogen. It sells at four to five cents per pound. It is nearly identical, in its effects on vegetation, with nitrate of soda.

Sulphate of ammonia is also manufactured, to a considerable extent, from the waste water in the manufacture of bone black, of charcoal and of Prussian blue, for wherever animal substances are roasted there ammonia is developed. These substances are not, however, in practice, roasted for the sake of obtaining the ammonia alone.

The other sources of nitrogen available to the farmer are slower and less sure in their action. The dried blood, animal meal, and fish scrap are all valuable, yielding five to ten per cent. of nitrogen, but not always in a readily available condition. The nitrogen in Peruvian guano is about eight per cent., and is in excellent condition as regards availability. Raw horns and bones, however, although rich in nitrogen, are ground with difficulty, and are decomposed so slowly, if applied raw to the soil, that judicious farmers usually prefer to depend on some more readily absorbed substances.

The question as to whether clover absorbs nitrogen from the air or not, is, I believe, considered doubtful by the best authority. Clover contains large quantities of nitrogen when taken in comparison with other crops, and for this reason is, in good practice, much used in rotation with grain; the clover roots and the manure resulting from feeding the clover hay proving excellent fertilizers for wheat and other grains. The statement of Secretary Chas. L. Flint before the Board of Agriculture, at the Waltham meeting in December, 1877, that Prof. Voelcker "found from two to three tons of nitrogen and its compounds" in the soil after a clover crop, per acre, and "that it was to a large extent in a form available for plant food," is about as loose and unsatisfactory a statement as could well be made upon this important subject.

What Prof. Voelcker does say is that an amount of nitrogen was found in the upper eighteen inches of soil, upon certain small patches taken as samples, which, multiplied by the number of thousand of such patches contained in an acre, gave the above result. He nowhere states what amount of this nitrogen was derived from the clover, or what was contained in the soil and in the air mixed with it before the clover was grown.

To jump at the conclusion that it was all due to the clover, is grossly incorrect, and likely to mislead. This amount of nitrogen would be worth $1,000 to $1,200 per acre, and naturally excited the attention of the shrewd Mr. Paul, who asked very respectfully if he understood the statement correctly, when the secretary repeated it.

Clover is indeed a valuable crop, and should enter more than it does into the economy of our farming, but it is hardly necessary to say that it is worth $1,000 or $1,200 per acre in order to convince farmers of its value or of the accuracy of our secretary.—*Boston Cultivator.*

## PROFESSOR HUGHES' AUDIOMETER.

DR. RICHARDSON, F.R.S., lately read two papers at the Royal Society, which have attracted much attention. One contained the description of a method by which the telephone is used to make the movements of the pulse audible, with a very remarkable result. The other paper was entitled, "Some Researches with Professor Hughes' new Instrument for the Measurement of Hearing: The Audiometer."

The instrument consists of two Leclanché cells for the battery, a new and simple microphone connected with the cells, and with two fixed cells (primary), and a secondary or induction coil, the terminals of which are attached to a telephone. The induction coil moves on a bar between the two fixed coils, and the bar is graduated into 200 parts, by which the readings of sound are taken. The graduated scale is divided into 20 centims., and each of these parts is subdivided into 10, so that the hearing may be tested up to 200°; from 200° maximum to 0° zero.

In using the instrument, one Leclanché cell has been found sufficient, as a general rule, but two have been used in instances where the hearing of the person under test has been very defective. The Leclanché cell was selected by Professor Hughes as affording a reliable current for the purposes he had in view, and for standard comparisons. In using the instrument, the induction coil is moved along the scale from or towards the larger primary, as may be required, and the degree of sound is read from the figures on the scale, the sound being made by the movement of the microphone key between the battery and the primary cell.

The person whose hearing is being tested should sit in an easy position, and should not see the act of the observer in moving the microphone key. For good observation, the room in which the observation is made should be large, and all external causes of sound, such as the ticking of clocks, the vibrations of windows and doors, the moving of feet, and the singing from gas-jets, should be silenced. The sitter should close the ear that is not applied to the telephone while he is listening for minute sounds, and should give his full and calm attention to the proceeding. Any excitement is like to lead to error when refined measurements are required.

*Capacity of the Instrument for Observation.*—The instrument may be considered the most satisfactory means for testing the hearing power of all persons who can define a sound. The range of sound is sufficient at the maximum—200°—for every one who is not absolutely deaf; 0°, or zero, is a point of positive silence from the instrument, or rather from the sound which it produces through the telephone.

*Phenomena from Observations made on Different Persons.—Abrupt Loss of Sound.*—One of the first facts learned with the audiometer is the suddenness with which the sound is lost on those who are listening. The sound is abruptly lost within a range of 2°, that is, within one hundredth part of the entire scale. This is the case with those who are very deaf as well as with those who hear readily, a fact originally noticed by Mr. Hughes, and which the author has corroborated by fifty special observations on different persons presenting powers of hearing which varied from 200° to 140°, as the extreme limit or capacity, to complete hearing through the whole scale down to zero. In these persons, when the observation was taken, under the strictest possible conditions for surrounding silence, the point between the distinctness of sound and complete loss of it was not more than one-hundredth part of the scale.

*Continuous Hearing in Line.*—In testing the capacity of hearing, it is noticeable that the power to detect the diminishing sound is maintained best by continuing the reduction in trace or line while the attention is fixed. A sudden break may cause the sound to be lost to the listener long before his real incapacity to hear is reached. If, for instance, the sound is very faintly heard at 15°, and the induction coil be suddenly moved to 5°, the sound at 5° may be quite inaudible; but if the coil be slowly moved, degree by degree, from 15° to 5°, the sound at 5° may be distinctly heard. Mr. Maitland Tate, C.E., who noticed this point very markedly in his own case, when the author was submitting him to test, compared this to what is observed by the sense of sight in making surveys. The eye will follow a line to an extreme point with comparative readiness, but if it break away from it the object seems to have disappeared.

*Influence of Respiration on Hearing.*—The effect of filling the chest and holding the breath makes a difference in listeners. The capacity for hearing is for a few seconds increased by holding the breath. Mr. Tate, who could hear with his right ear only down to 8° under ordinary breathing, could hear down to 5° when he held his breath. Another gentleman, who could hear only down to 100° under ordinary breathing, could hear to 80° when the breath was held with the chest full. Holding the breath with the chest not full fails to produce the same result.

*Influence of Habitual Movements of the Body.*—As a rule, the hearing of persons who are right-handed is most refined in the right ear, and as most persons are right-handed, it is found that the right ear is the best ear. This rule is, however, attended with many exceptions, since, for various reasons, persons who use the right hand exclusively, practice for some particular purpose the use of the left ear, upon which that ear becomes more acute. Thus five physicians, who had accustomed themselves to use the stethoscope with the left ear, could hear to zero on that side, but had lost from 4° to 5° on the right side. Four other persons who were similarly circumstanced, were able at once to account for the fact by the habit they had acquired of listening to a public discourse or sermon from the left side. The interest attaching to this observation is, that the practice of using one ear for special refinement of sense seems for the time slightly to impair the other ear, although there is no physical evidence of such impairment.

*Influence of some Automatic Adjustment and of Memory and Hearing.*—Connected with the last named fact is another, namely, the deaf are found to fail in capacity of hearing, not only by reason of physical defect, but also by failure of memory of sounds. Thus, in a youth who had suffered serious defect of hearing for seven years, owing to partial destruction of the tympanum, and who in the right ear could only detect sound at 107°, there was an inability to catch all the sound lying between 130° and 107°, until he could remember what he had to listen for. By practicing him then to detect the lowest sound that he was physically capable of receiving, the author got him to detect this one sound more readily than those which came higher up, between 107° and 130°. By further practice, all the intervening sounds became audible with equal facility. These facts, which have been confirmed by another observation on a different person, seem to the author to indicate that deafness from imperfection of the tympanum, or other parts of the organ of hearing, may be measured, beyond the mere physical failure, from some lost power of automatic adjustment in the auditory apparatus, and from failure of receptive power in the cerebrum itself, so that the memory, rendered imperfect, is slow to assist the listener, until by exercise of function its readiness is restored.

*Influence of Atmospheric Pressure.*—By use of the audiometer, the influence of atmospheric pressure on hearing is detectable. In the author's own case, when the barometer is 30°, he can hear on both sides close down to zero; but below 30° he fails by 2° on the left side to reach zero. In another person the failure under the same pressure extends to a loss of 4°.

*Observations on Lower Animals.*—The author tried to determine in some of the lower animals whether there is the same sense of hearing as in man. In most animals it is difficult to obtain sufficient quietude to enable the observer to gather from expression or movement of the animal, the information sought for. In two dogs, one a terrier, the other a field spaniel, the author succeeded in making some good observations, and in them the range of hearing power seemed to be distinctly lower than in the human subject who has perfect hearing. In both these animals, which were healthy and in the prime of life, the first indication of the detection of sound commenced at 10° on the scale. The detection was evidenced by the sudden expression of listening, by a slight change of position, and a slight dilatation of the pupils. This detection was clearly made on the instant, as if the fact of hearing were abrupt, as it is in the higher animal.

Dr. Richardson concluded his paper with a statement of his views as to the uses to which this instrument may be put, among which are the following:

The audiometer will, he thinks, be an essential in all physical inquiries of men who are undergoing examination as to their fitness for special services requiring perfect hearing, such as soldiers, sentries, railway officials, and the like.

The instrument will be of great use to the physician, in determining the value of hearing in those who are deaf, and in determining the relative values of the two organs of hearing. In one instance, already, he has been able by its means to detect in a person, who was supposed to be equally deaf on both sides, that on one side the hearing is perfect close up to zero; while on the other side nine-tenths of the hearing is lost.

The instrument may be used to differentiate between deafness through the external ear and deafness from inclosure of the Eustachian tube—throat deafness. In his own case the author fails to detect sound by the mouth at 170°, and this is a fair average in those who are healthy. It represents the comparative value of communication by sound through the Eustachian canal and the external ear.

The instrument promises to be of great service in determining the value of artificial tympanums, in instances of deafness due to imperfection or destruction of the natural tympanum. The cotton artificial tympanums, introduced originally by the late Dr. Yearsley, and the membranous tympanums introduced by the late Mr. Toynbee, F.R.S., have proved of much service; and by means of the audiometer Dr. Richardson has been able very accurately to test their respective merits, and to compare both with tympanums made of other material.

## THE SOUNDS IN THE TELEPHONE.

IT has been observed that since speech may be reproduced in many different ways, each system of telephone may transmit it by multiple means, that is to say, by the influence of different causes, and that the Bell telephone, for instance, may produce the repetition of articulate sounds at the same time by the magnetic core, by the diaphragm, by the coil, and by the wooden envelope of the telephone itself. It is added, however, that, in this apparatus, the sounds produced by the diaphragm should be the most appreciable.

It is certain that the diaphragm, by reason of its greater proximity to the ear, and of its smaller magnetic inertia, should, in accordance with the theory of its effects, given by M. du Moncel, give more characteristic vibrations than the magnetic core, and the parts in connection with it. But, according to him, and in our own opinion, these vibrations would be the result of electro-magnetic attractions only when currents of sufficient intensity, that is to say voltaic currents, are employed. With the induced currents produced by the Bell telephone—currents of which the intensity may be represented by that of a Daniell element making the circuit of the world 290 times, through a telegraph wire 4 millimeters in diameter—these attractions are impossible, and we are forced to admit that the vibrations produced in this case are the result of molecular effects determined by the magnetizations and demagnetizations of the diaphragm under the influence of the magnetic core. Thus, these effects would be completely analogous to those produced in the magnetic core itself, and, consequently, would be due to the same cause.

It is time that it was urged, in answer to M. du Moncel, when he supported this theory, that the sounds produced directly by actions exerted upon magnetic cores could be obtained only by means of somewhat considerable electrical forces, and consequently could not be the result of feeble currents such as have just been referred to. The experiments of M. Ader have demonstrated that speech could be very distinctly reproduced by means of an iron wire; but for this purpose it was necessary to employ from three to six Leclanché elements. In order to overcome this objection, M. du Moncel undertook a series of experiments which showed that speech could be clearly reproduced by the currents of an ordinary Bell telephone when the receptor was constituted by a fragment of watch-spring strongly magnetized and attached by one extremity to a board. If to this spring is adapted a helix of very fine wire, placed against the board, and allowing one end of the spring to project, speech may be heard, very clearly, more clearly even than with a speaking microphone, when the board is applied to the ear. In this case it is quite evident that molecular vibrations alone can occur, and yet such feeble currents as those employed suffice to reproduce speech. It is necessary, therefore, to regard the old theories of acoustics as being no longer at the level of actual science; and, whatever a few obstructive *savants* may say, they will in future have to take into consideration molecular movements and the sounds that may result therefrom.

Mr. H. Wildbrand has recently published in *L'Electricité* of June 5, certain experiments which are most conclusively in favor of the theory here set forth.—*La Lumière Electrique*—*The Electrician.*

## ELECTRIC LIGHTING IN PARIS.

THE electrical illumination of the Palais de l'Industrie, in which the Horticultural Exhibition was lately held, is entirely on the Jablochkoff system, and the whole installation was completed by the company in a week, a very short space of time, considering the large number of "candles" (256) and the amount of power (260 h. p.) required to drive the machines. In the absence of comparative dimensions, the main building of the Palais may be considered about as large as the Agricultural Hall, longer, but not so wide. It is provided with sixty Jablochkoff candles, inclosed in the usual opal globes, of which about half are standards, and the rest pendent from the galleries. It must be confessed that, though the light is perfectly suited to set off an exhibition of plants interspersed with statuary, exercising no injurious effect on the latter as gas would do, the number of lights was insufficient for perfect illumination. In the galleries above, however, where the pictures are hung, the result is far more satisfactory. Here pendent lights are placed about 30 feet apart, and the globes are frosted, thus allowing probably 90 per cent. of the light to penetrate them, instead of only 50 per cent. as with the ordinary opal globes. In addition to this the rays are confined, and to some extent thrown on to the pictures by metal shades.

For the motive power and electric machines a shed has been put up on the south side of the Palais, containing four engines of the Société Centrale de Construction, Pantin, Seine. The sheet iron stacks, affording mutual strength, are led up together above the main building, while the exhaust steam—so much of it, at least, as is not condensed in a feed-heater—is carried up by a pipe in the middle of these stacks. The engines are of the compound semi portable type, two of 100 and two of 30 horse power. Each small engine drives two Gramme electric-light machines with its *excitatrice*, or ordinary Gramme machine for magnetizing the inductor of the former, and also for intensifying the alternate currents. The two large engines work with two pulleys and belts, each on to a main shaft, pulleys and belts from which drive twelve electric-light machines, with their *excitatrices*. Each dynamo-electric machine supplies electricity for four circuits with four candles each.

A great improvement has quite recently been introduced into the method of changing the candles. In the Avenue de l'Opéra, a man has to go to each lamp when the candle is nearly consumed, and, by means of a switch, turn the current from this to a new candle. Now, however, a switch or commutator is placed in the circuit near the operator, by means of which he can momentarily interrupt the current, thus throwing out the candles burning, and then immediately re-establish the current, obliging it to pass through whichever of the remaining candles in the lamp presents the least resistance. In the arrangement at the Palais de l'Industrie all the commutators, which are little disks of wood with metal connections and binding screws for the wires, are arranged on a board and numbered, so that the operator can renew or extinguish the lights of any circuit he pleases. By means of a small key inserted in the center of the disk he turns the switch so as to break contact, and then immediately re-establishes it, the interruption lasting only a quarter of a second.

While on the subject of the electric light it may not be amiss to conclude this article with a few details of the illumination of the Hippodrome, which afforded interest to many Paris visitors last year. Two 100 h. p. compound engines of the Société Centrale, named above, drive twenty-four ordinary Gramme machines and three multiple-current machines. These latter, with three of the former for their *excitatrices*, supply the current for sixty Jablochkoff candles, while the remaining Gramme machines (one probably being in reserve) actuate twenty Serrin lamps. The lights are judiciously disposed, and the effect is all that can be desired. Although there are a great many gas jets in addition, they serve rather for effect than to increase the illuminating power. All the lights are arranged so that they can be got at easily without the use of ladders. The twenty Serrin lamps or regulators, as they are called, with reflectors, are inclosed in trucks made to slide in and out, for cleaning, etc., on the nearly flat portion of roof over the spectators. Twenty of the Jablochkoff candles are carried by brackets pivoted to the columns supporting the main girders of the building, and capable of being swung round within reach. Twenty more are hung between these columns, and may be lowered to the floor; and the remaining twenty are disposed in clusters of five each on the four large columns that support the girders on which slides the movable roof. The whole cost, including maintenance and interest on capital, is set down at 300 fr. for a performance; that is to say, 100 fr., or £4, an hour, which is regarded as cheaper than gas, while being far more convenient. The Jablochkoff system is also used for the illumination of the exhibition of paintings by ancient masters and at the outdoor instrumental concert of the Champs Elysées.

## A NEW SYSTEM OF TELEGRAPHY.

PROFESSOR ROYAL E. HOUSE, of Binghamton, N. Y., the well-known inventor of the House printer, has recently patented a new invention, which, if all that is said of it be true, seems destined to exert at least an important influence on the future of telegraphy, if, indeed, it does not in a marked degree, revolutionize the entire business.

Mr. House has spent about twelve years in experimenting with the new system, and by its aid, as now perfected, he claims to be able to transmit intelligence not only much cheaper and quicker than can be done by the instruments and apparatus at present in use, but with almost absolute correctness. Nor is this all. An office can be called, a response obtained, and a message sent and recorded without a "break," and even in the absence of the operator.

It is possible also to send a message to any office on the line in such a manner that no other office but the one for whom it was intended can know its contents; while again, all the offices can be communicated with simultaneously—for the purpose of transmitting press reports for instance—as in the present Morse system. The time required to call up an office, and send an ordinary dispatch by the Morse system, is reckoned at two minutes, and the average cost of each message at about twenty-six cents; but Professor House believes that he can send the same message in six seconds, and at a cost of only two cents and five and a half mills.

The wires used between stations are the same as those now employed. So—with the exception of a slight adaptation to this system—are the batteries. A new alphabet is used by which each break, or close, or reversion of the circuit forms a letter, or separates the words of the message. There are three separate instruments or machines. Number one, which is about the size of an ordinary sewing machine, and can be run by foot, water, or steam power, corresponds somewhat

to the perforating machine of the automatic system. As described by a local paper, it has a key-board, with keys lettered, and numbered corresponding to the alphabet and numerals with pauses, etc., somewhat like the key-board of the ordinary type-writer. Attached to it is a roll or fillet of paper about one inch in width, similar to the paper used with the old Morse register. The operator manipulates the key-board, touching a key for each letter of the dispatch. At the same time the narrow strip of paper commences to pace rapidly over two small, lance-pointed knives which strike it from below, cutting in it, each time they strike, a slit, the same as would be made by the point of an ordinary pen-knife blade if drawn over a piece of paper on a table. These two knives cut parallel with each other, and each slit so cut represents a letter. They cut in rotation, that is, in spelling a word one letter is cut about a quarter of an inch from one edge of the paper by one knife, and the next letter is cut by the other knife, a corresponding distance from the other edge of the paper, thus making two rows of slits, but none of them opposite each other. These slits are called symbols, and their varying length gives them their individual character as letters or figures. On the paper, after it is cut, they present an appearance similar to the following:

This work is performed very rapidly. The fillet of paper, thus prepared, then contains the whole message, and no more brain-work is required of the operator. All the rest is mechanical, and done entirely by automatic machinery. The fillet then passes to machine No. 2, which is the wonderful and important portion of the invention, and where electricity is introduced. The exact counterpart of this No. 2 machine is required in every office on the line. It is entirely automatic in its action, and, being started, will run and transmit news indefinitely.

Each of these machines has a feed cylinder which is always in motion. Through this feed cylinder the paper which has been prepared or cut in machine No. 1 is passed. Pressure is brought upon this cylinder by simply touching a small lever, and the desired station is thus called.

To explain: Every station has a "symbol" or call, in the same manner as under the present Morse system. These symbols are different from anything which can occur in a message. By an ingenious mechanical arrangement, a wheel, arranged with small sliding bars entirely around its rim, is attached to every machine. Like a combination lock, or any other combination, this wheel is capable of many combinations. A combination, then, on this wheel, corresponds to the symbol or call of an office, and the machine of that office is so set, that when any other machine calls for this combination or configuration, as it is termed in the patent, pressure will be put upon the feed cylinder only of the machine so called, and not upon any of the others on the line.

When the fillet of paper is prepared by the operator, the call or "symbol" of the station to which it is to be sent is cut into the paper in the same manner as, and just preceding, the message. This paper then passes to machine No. 2. In this machine are arranged small blades, the exact counterparts of the knives which have cut the call and letters in this paper, but which are not sharpened. The end of the strip or filler, which comes from machine No. 1, is passed between two rollers, and over these blades; and as the slits in the paper are reached each blade penetrates the slit, remaining in it just as long as the slit is long. That is, each blade does just what the blades did which cut the slit, except they do not cut anything. They simply enter and leave the slits which have been cut. This opens and closes the circuit.

When the end of a fillet of paper, the "symbol" and message having been cut in it by machine No. 1, is put into the feed cylinder of machine No. 2, and the lever touched, the sending operator's work is done. To every machine No. 2 on the line there are two sets of blades, one for receiving messages, the other for sending messages. As soon as the machine at the receiving station commences to run, it first answers the sending station by an automatic signal, and then a roll of uncut paper begins to pass over set of knives No. 2, which are sharp, and cut the paper, the same as the knives in machine No. 1, which is used to prepare the paper in the sending office. These knives are worked and controlled by the current which the blades at the sending office open and close, and, consequently, cut in the paper at the receiving end, which is passing over them, the exact counterpart of the prepared fillet which has been placed in the sending machine. The receiving office now has a message recorded in the office there, and the operator may have been up at home and asleep, if need be. The message consists of a long strip of paper full of slits of various lengths. This is then passed through machine No. 3. This is an automatic printing machine. The slits are again penetrated by blades, and mechanism, simple in character, gives an impression from a type wheel corresponding to the letters represented by the slits, and the message is printed ready for delivery. This printing machine is a small affair, perfect in its workings, and a twelve year old child can tend it as easily as a cradle.

It is stated that anybody of ordinary brains can operate all the instruments. For press use dispatches could be delivered to the papers in the fillet or roll, and the running of these fillets through the printing machine done by each individual paper. A time "governor," adjustable by a pendulum, keeps the several machines so adjusted that the speed of each will exactly correspond, thus preventing the blades, which open and close the circuits, from tearing the paper or enlarging the slits. Professor House thinks that his new invention solves the problem of postal telegraphy, and calls it the House Postal Telegraph System, and those who have seen it say that it is peculiarly adapted for such a purpose.—*The Operator.*

## PHYSICAL SOCIETY, LONDON.

*Suppressing the Induction Disturbances in a Telephone Circuit.*—It is known that a secondary battery, composed of metal plates and sulphuric acid, allows weak currents to pass while stopping those of high tension. Prof. MacLeod therefore inserted a secondary battery of platinum plates between the line and the telephone, but this stopped both the induction and the vocal currents. When platinum wires were substituted for the plates, however, the induction currents were stopped, while the vocal currents could be feebly heard.

*New Reversing Key.*—Dr. O. J. Lodge exhibited his new reversing key for electrometer work, which is preferable to the ordinary forms, as giving a high insulation, small capacity, and not requiring the hand to approach close to it to work it. It consists of four platinum wires, arranged in pairs, crossing one another; one pair crossing between the other two. These are the terminals and contact pieces of the key. The middle pair are supported by an endless silk thread, which runs on two pulleys, one of which is fitted with a handle. On turning the handle to right or left, the two middle wires are brought into contact with one or other of the two outer wires, and the current reversed at will. The whole is inclosed in a metal box.

*Electric Discharges in Vacuum Tubes.*—Mr. J. F. Moulton demonstrated the results of the experiments of Mr. Spottiswoode and himself on the sensitiveness of electric discharges in vacuum tubes. These experiments were undertaken to find the cause of the numerous layers or strata in the discharge, a Holt machine being employed. It was observed that when feeble currents were drawn from the machine, the discharge could be depressed by laying the finger on the tube, and this depression always occurs with intermittent currents; therefore the feeble currents from a continuous current Holtz discharge themselves like intermittent currents by reason of their feebleness. This sensitiveness of the discharge to the approach of the finger was found to be due to the conductivity and electric capacity of the hand. Electricity, opposite in kind to the discharge, is induced on the finger, and streaming upon the tube neutralizes part of the discharge therein. This effect was also shown by means of tin foil rings round the tube. An intermittent current is of course capable of this static induction on neighboring conductors. The luminous discharge in a vacuum tube consists of a bright sharp glow at the negative terminal, followed by a dark space, then a hazy bluish light at the positive pole. The striæ or layers in these sensitive tubes merely repeat this appearance. They can be artificially produced by placing the fingers, or rings of metal, at intervals along a tube conveying an amorphous discharge; for in this case the induced electricity discharging itself from the fingers breaks up the amorphous discharge into dark and bright layers. In these stratified discharges the electricity appears to travel *per saltum*, or by stepping stones, as one may say, and the glow seems to be a molecular structure, a view which is supported by Mr. Crookes' experiments. A negative discharge from the finger produces a dark space in the tube discharge, and a positive one a bright line; therefore, one can tell the kind of discharge passing in a tube by laying a finger on it. If the same pole be brought to both ends of a tube, a discharge will take place from each end, and there will be a dark space in the middle, the electricity here seeming to turn back again the way it came. The discharge from the pole through a vacuum tube would therefore appear to be not akin to a conduction but to a disruptive discharge. It is a leap in the dark, and the phenomena observed are due to the gaseous nature of the medium. These experiments point to the possibility of completing a circuit by positive electricity alone.

Professor Guthrie suggested that by combining vacuum tubes with the induction balance of Prof. Hughes, it might be possible to get an optical balance for measuring inductive capacity.

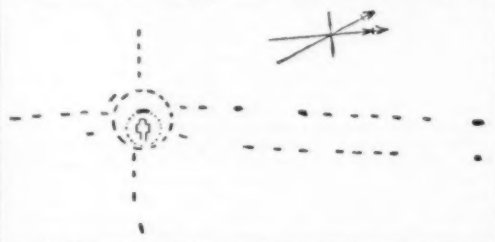
*Oxygen in the Sun.*—Dr. Henry Draper, of New York, who is now on a visit to England, then addressed the meeting on his alleged discovery of oxygen in the sun by bright lines in the solar spectrum. He said that hitherto he had not been able to find these lines projecting from the limb of the sun like hydrogen, and his impression is that oxygen resides lower than the reversing layer. He had lately been extending the dispersion of the spectrum of terrestrial oxygen, and from a light of maximum intensity of one candle power had now got a dispersion of 80 inches from A to O. He exhibited two of the original negatives of the solar spectrum, showing the bright lines.

## THE STANDING STONES OF CALLANISH.

THE object of the present paper is to describe the standing stones of Callanish, Island of Lewis, accompanied by notes of such measurements as the author was able to take during a somewhat hurried visit to these very interesting memorials of the early inhabitants of our islands.

Leaving the town of Stornoway, we soon find ourselves amongst great tracts of moorland, with sheets of water large and small on all sides. The deep black peat is being cut and piled up into stacks, when, after being dried, it will serve for the winter's fuel. The peats in the Lewis are broad and thin, and not so brick-shaped as those on the mainland further south. All around wears a somber aspect. Miles and miles of bog and moorland, without tree or bush to break the long undulatory lines which rise and fall like the waves of the sea.

At length, as we reach the top of a slight rise, we see before us the object of our visit, the stones appearing so thickly clustered together on the rising ground on which they stand, as to suggest the likeness to a cemetery. Leaving the vehicle a little beyond the sixteenth mile-stone from



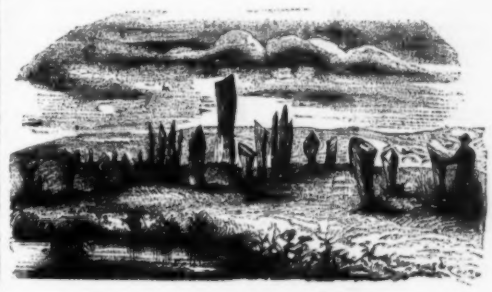
PLAN OF GENERAL ARRANGEMENT OF GROUP.

Stornoway, we ascend by a roughly causewayed roadway which leads from the main road to the top of the low hill upon which the stones are placed. On a closer inspection it is found that the general outline is cruciform, and at or near the intersection of the cross limbs is placed the largest stone, whilst around is a circle of tall stones. The stones are rough, and appear only to have received such dressing as would bring them to a suitable shape for erection; they are composed of the rock of the island, the Laurentian gneiss, which, in geological record, is the oldest known. In color it is grayish, with occasional flesh-colored patches. The stones are monoliths, and are all upright.

The upper parts of the stones are covered with a grayish green lichen, the lower parts being comparatively bare. This is accounted for by the fact that a number of years ago the proprietor of the island caused the peaty ground around to be removed, which showed that the height was much greater than had at first appeared; the parts thus recently disclosed have not the heavy coating of lichen which the upper parts have; the line separating the two parts is very marked. From this the great age of the stones may be inferred, as there has been an accumulation of peaty soil of about five feet deep.*

From a careful inspection of the stones the author found the number to be forty-eight. (The driver's remark on being asked the number was that they could not be counted over by different people and made the same.) The highest stone is about 16 feet, and the stones forming the circle are next to the central one in height, varying from about 8 feet to 11 feet. The others vary from about 7 feet to about 4 feet.

The longer limb of the cross is composed of two rows of stones placed about 27 feet apart, there being ten stones on the west side, and nine on the east side. This is a very distinct feature in the arrangement, as there is thus an avenue leading to the circle. The circle consists of thirteen stones, and the western and eastern cross arms have each a single line of four stones, whilst the southern limb is composed of six stones; the whole with the central stone and one outside and close to the circle makes forty-eight. The general arrangement will be more readily understood from the accompanying plan, which is drawn approximately to scale. From careful observations with a pocket compass, the general bearing of the northern limb was found to be 30° to east of magnetic north; it was also found that, when a line was projected from the flat side of the endmost southern stone,



VIEW FROM NORTH EAST.

it cut exactly the end stone of the western side of the northern limb; the latter stone measures about 11 feet in height. If the compass variation be estimated at 25° west (the latitude is about 58° 12′ north), it appears that the main axis of the group lies about 5° to *east* of true or polar north. Several of the stones besides the one already mentioned appear to have a *directive* tendency, notably the one next the circle in the eastern side of the northern limb; this stone, both from its pointed shape and flat form, leads the eye to the center of the circle. The whole series, indeed, are arranged with their narrow faces pointing in the line of setting; this is easily noticed, as the stones are generally flat, thin, and slab-like. The circle stones have their broadest faces turned to the center of the circle. The great stone is situated at or near the center of the circle; it measures about 16 feet in height, with a breadth at bottom of 5 feet, at middle of 4 feet, and upper part 3 feet 6 inches; its thickness is one foot; its flat side faces the east. This stone must weigh about six tons.

The general dimensions of the group are as follows:

Extreme length, 128 yards; length of northern limb, 85 yards; diameter of circle, 14 yards (this measurement is in a north and south line; from east to west the measurements gave 13 yards, so that the figure is slightly elliptical); length of southern limb, 29 yards; extreme breadth, 44 yards; length of western arm, 13 yards; length of eastern arm, 18 yards. The whole figure roughly resembles the Iona cross in outline. In or near the center of the circle there is a hollow, roughly rectangular on plan, measuring about 7 feet long, the breadth at center being 6 feet, and at ends 5 feet, narrowing, however, at the eastern end, so as to form a kind of channel leading outwards. The sides of this hollow are built by small stones, and four large stones are placed so as to break up the whole into two chambers. The direction of length of this hollow is east and west; the tall central stone already described being situated near to and facing its western end. It is said that a stone cover was found upon this hollow when first discovered. The hill upon which the stones are placed slopes downwards to the north; the ground on which the cross arms are placed is about level. Another circle of tall stones still stands about a mile to eastward, from which it appears that the peat has been recently removed.

From an examination of the stone circles of Arran, the late Dr. Bryce found that stone cists in some cases existed at the center of the circles, and that the longer lengths of these cists, as also the longer axis of one elliptically-shaped series of stones, were all lying about north and south, or inclining rather to east or north.

In the Smithsonian Report for 1876 there is a description of mounds and lines of stones in Guatemala, the long sides and directions of which were about 5° to west of magnetic north; they vary from two feet to six feet in height. This would leave, after allowing for the easterly variation of the compass there, a probable direction of 5° or 10° to east of true or polar north. A certain similarity, therefore, appears to exist in the setting out of these groups, with a tendency to a direction east of north.

The country people called the place Callanish, not Callernish, as sometimes given, the meaning of the former name having been defined as "place of assembly for worship," whilst the latter is given as "bleak headland." The title Fir Bhreige, or false men, is sometimes given to the group, from the apparent motion of the stones as the spectator changes his position when viewing them from a distance.

The erection of such circles as that of Callanish has been popularly attributed to the Druids, and according to this theory the Callanish circle would have been a religious meeting-place. Again, it has been supposed that they were tombs of warriors, and may have been erected by the early Norse rovers. Others look upon such groups of stones as places for judicial meetings which might have been accompanied by religious ceremonies.

The general impression which one gets from standing amongst the Callanish stones is that the long avenue was intended as an approach from the not far distant shore for a large body of people, who would thus converge toward the central circle.—*W. J. Miller, in Nature.*

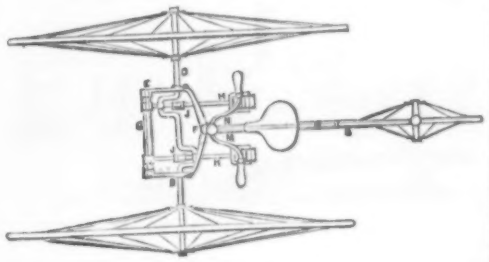
* It is difficult to get reliable data as to the growth of peat-moss, but taking about 300 years to the foot, a depth of five feet would infer a period of about 1,000 years since the peat commenced to form. In Black's "Guide" it is stated that the stones rest on a causewayed base. As there was no trace of this at the time of the author's visit, seeing that there was a vegetable growth all around, some data as to rate of growth of the peaty soil might be got, as it is about twenty years since the excavation of the peat took place.

## NEW VELOCIPEDE

WITH the view of utilizing large driving wheels while keeping the seat at a convenient distance from the ground, the treadles of velocipedes have been arranged in connection with levers, spur wheels, chains, etc., in a variety of ways, one of which we illustrate this week, as a good examples of modern invention in connection with tricycles or four wheeled veloces.

The cut shows a plan view of a tricycle, showing the method adopted by Mr. R. Harrington, of Wolverhampton, England. The tricycle is constructed with two wheels in front, one being fixed at one end of an axle having two cranks opposite centers, and the other being placed to turn freely on the other end of the axle, and with a small steering wheel behind. The framing consists of a backbone (similar to the backbone of a bicycle) rigidly connected to a front fork. The front wheels are outside the bearings, and the cranks are preferably between the bearings. Each side of the fork is continued below the front axle bearings, the lower ends of the fork being preferably forward of the center of the axle. The two lower ends of the fork are connected together by a cross bar. The cross bar acts as a fulcrum to two levers which extend backward therefrom and terminate in treadles

From a point between the fulcrum and treadle of each lever a connecting rod passes up to one of the cranks. The backbone is connected at its back end to a socket on the hind fork. Steering handles (similar to those of a bicycle) are



carried in the top of the front fork, and are capable of being turned freely therein. A lever connected to the steering handles actuates a lever connected to the hind fork (through the medium of a pin and slot), or rods or chains or other equivalent connections pass from the steering bar to projections on the hind socket, the said rods or chains (if used) being preferably crossed, so that the handles are turned precisely as in a bicycle. The saddle is mounted on a spring upon the backbone.

This tricycle, says the *English Mechanic*, may be adapted for the use of ladies by making the backbone double on plan, so as to leave room between the two sides for the dress, and mounting the seat on a spring extending from side to side.

The spokes of the wheels are fixed by passing the wire through holes drilled or slotted out of the projecting edge of the hub, and screwing each spoke tight by means of a nipple passed through the rim from the concave side thereof. The nipples are kept in place by means of countersunk heads, which prevent them from being drawn through the rim, but allow them to be turned round. Each spoke has a riveted head at the hub to prevent it from being drawn through the hole in the hub, and is screwed into the nipple in the rim by turning round the nipple. In case of the fracture of a spoke, it may be removed and replaced without removing the rubber tire.

In the drawing the axle, C, is shown with two cranks set opposite to one another. B is the steering wheel. The framing consists of a backbone rigidly connected to the front fork, F. The cranks are preferably inside the bearings, D, as shown. The fork, F, is continued below the front axle bearings, and is bent slightly in advance thereof, as shown at E, the two ends being connected together by a cross bar, G. The cross bar, G, acts as a fulcrum to two levers, H, H, which terminate in treadles. J, J, are connecting rods passing from the levers, H, H, to the cranks. The backbone is connected at its back end to a socket on the hind fork. M is a steering bar which is carried in a socket at the top of the front fork, and is capable of being turned freely therein.

The pin upon which the bar, M, turns passes through the socket, and is rigidly connected at its lower end to a lever, N. Motion is thus given to the lever, N, by means of the steering handles. O is a lever fixed rigidly to the hind fork. The lever, O, is moved by the lever, N, through the medium of a pin fixed in the lever, O, and sliding in a slot in the lever, N (see dotted lines).

## STOP-COCK OF EASY CONSTRUCTION.

TAKE two glass tubes, one of which slides easily into the other, close the end of the smaller tube in the flame of a Bunsen's burner, and make an opening about an inch from the closed end by filing crosswise with a rat-tail file. Connect the two tubes by a piece of rubber tubing, which should fit the smaller tube closely, and the stop-cock is complete.

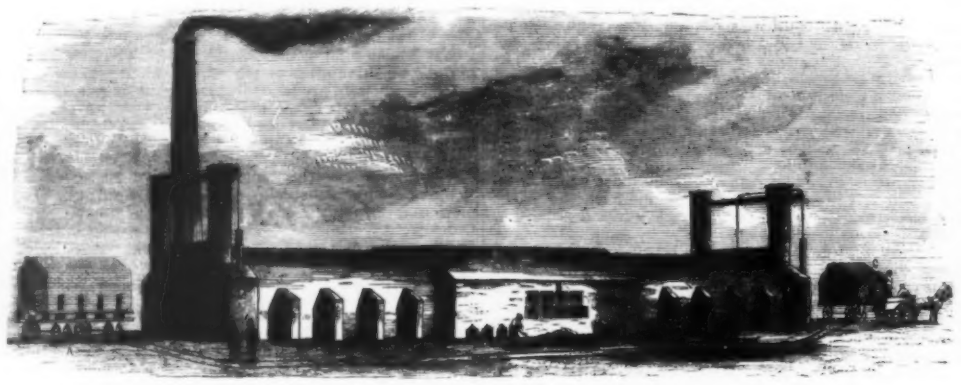
Fig. 1.

Fig. 2.

When the smaller tube is pushed into the larger one the cock is open; when shoved back into the rubber tube the opening in the small tube is covered by the rubber wall, and the passage of liquids or gases prevented. The accompanying figures make this clear. Fig. 1 represents the cock open. Fig. 2 shows the cock closed.—*Edward Hart.*

## RAILWAY BRICK KILN.

THE accompanying illustration represents the tramway kiln of Messrs. Foster & Foster, of Normanton, Eng. It is essentially a long shed, well closed in of course, the central third being heated by fires in the usual way. The ends are closed by sliding wrought iron doors, properly balanced, and a line of rails runs from end to end of the kiln, connected as necessary with sidings outside. The method of working is remarkably simple. As made, the bricks are loaded upon trucks, each truck holding about 5,000. As soon as a truck is full, it is run into the end of the kiln, where the heat is sufficient to dry the bricks without burning. When a second truck is full, it may be placed in the kiln, the first being pushed on a stage to a hotter section. By the introduction of other trucks the first is brought within the range of the fires, which are placed high enough to affect the body of the truck as little as possible, their power being concentrated upon the load of bricks. A repetition of the operation gradually drives the burnt bricks out of the heated section to a cooler part of the kiln, and when a truck load is withdrawn at the end opposite to the entrance, the bricks are cool enough to be handled, and they can be unloaded on to carts or railway trucks for carriage. There is thus no wicket building or plastering, and no great necessity for careful regulation of heat—two points in which expense and labor are saved—while time and labor also is economized by drying the bricks on the trucks instead of floors. The chimney stack is at the entering end of the kiln, so that the moisture from the fresh bricks is carried off without passing near the burnt and cooling bricks.



RAILWAY BRICK KILN

A few other advantages are claimed for this form of kiln. Its first cost is not excessive, amounting to from £600 to £800, while the running expenses for labor to make and burn 20,000 bricks daily do not exceed £2 10s. per day. All the material used in its construction can be used again, for building purposes, after the kiln is no longer required, so that the need for a kiln being merely temporary can hardly be an objection to building one. The fires being stationary, very few firebricks are required, and as there are no underground flues, the erection is not very expensive. The cost per thousand for fuel is stated to be about sixpence, so that however small the production there ought to be a profit. An instance of the extent to which labor is reduced by this means is found in a brickwork where, after leaving the brick machine, each brick is only once touched by the hand until loaded into carts and trucks for conveyance. In this case we are informed that five thousand bricks are well and evenly burned every five or six hours.—*Iron.*

## THE GRAVITY ROADS OF PENNSYLVANIA.

THE two great gravity railroads of Pennsylvania are the Delaware & Hudson Canal Company's road between Honesdale and Carbondale, and the Pennsylvania Coal Company's road between Hawley and Dunmore, a suburb of Scranton. The former is 17 miles long, the latter 33 miles. A correspondent of the New York *Times* says:

The Delaware and Hudson Gravity Road was the first practical railroad completed in America. It was part of the gigantic scheme of William and Maurice Wurts, the Philadelphia Quakers, of connecting the coal mines they discovered in the Lackawanna Valley with a market at tidewater on the Hudson. They conceived the idea of the Delaware and Hudson Canal, and completed that great work in the face of almost universal opposition. Their mines—the first opened in the Lackawanna Valley—were 16 miles from the nearest point they could make the eastern terminus of the canal. So, in 1828, the railroad was constructed over the lofty Moosic range of mountains. The civil engineer of to-day marvels at the genius that, at a day when the simplest of tramways were looked upon as wonders, dared project a railroad that was to climb to the summit of a mountain 2,000 feet high, and follow its sharp escarpments for 17 miles. The road, until 1877, was used exclusively for coal transportation. In that year the company placed a number of passenger coaches on the road as an experiment. They were so remunerative that they have been run ever since and their number increased.

The traveler who enters one of these novel little cars at Honesdale for the first time will be surprised and puzzled at what he sees. The car is nicely upholstered, but it is not more than half the size of an ordinary passenger car. It moves out from the covered depot a few yards and stops. The traveler looks out and sees the track leading straight ahead, but directly up the side of a hill, at an angle of about 60°. There is no locomotive anywhere in sight, and the top of the hill is nearly a quarter of a mile away. A train hand stands on the front platform. He holds in his hand a heavy chain, with an immense hook at each end. A large iron cable, resting on iron pulleys between the rails, extends from the foot of the plane to the summit. Suddenly the brakeman inserts one of the hooks in a sling attached to the car, and the other one in a sling on the endless cable. Another man pulls shortly three times on a wire that, suspended by rings on wooden posts, runs up the hill at the side of the track. Almost instantly the car starts, and makes up the hill at the rate of 15 miles an hour. There is no visible motive power. The car is drawn up the hill by a stationary engine at the summit or head of the plane, by means of the endless wire rope which winds and unwinds from huge iron drums. These engines are most elaborate and powerful machines, and are reversible in movement like a locomotive. After reaching the summit of the plane just described, the car runs on a descending grade of about 50 feet to the mile by its own gravity for four miles. Then another plane is ascended. Between Honesdale and the summit of the Moosic Mountain, 10 miles, eight planes are raised, and then the traveler is 2,000 feet above the sea. From this point he looks down on a landscape that extends to the east and south for over 60 miles, the Catskill Mountains being plainly seen as the furthest boundary.

From the summit plane to Carbondale is seven miles, over an uninterrupted decline. It is impossible to imagine the intricate curves and windings the road makes in its course. The flight of the train down the mountain, sometimes rushing along at the rate of a mile a minute, is a most exhilarating and thrilling experience. The "runner," as the brakeman is called, stands on the platform of the front car, with his hand on the brake, and controls every movement of the train. He can send it along at the speed of the wind, or bring it to a stand-still at his will. No smoke, no cinders, no dust annoy the tourist. Only the freshest of mountain air, of which the open cars permit the fullest enjoyment, and the most charming and varied of scenery. At one point on the down-mountain side the road brings the tourist within a mile of Carbondale. The city lies 800 feet below, in the valley, and a stranger might imagine that he was about to rush down into the city. But suddenly the train dashes around an abrupt curve, and goes thundering in another direction along the face of the mountain, and the city disappears. The road runs five miles around to make its entrance into Carbondale. Two miles from the city the tourist will see a track running parallel with the one he is riding on. It is 15 feet away, and 20 feet below him. The universal impression is that this is a different road. This point, however, is the remarkable curve known as "the Shepherd's Crook." In order to get around certain obstructions, the engineers were obliged to lay the road out on a curve so abrupt that it assumes exactly the shape of a shepherd's crook. This is a most puzzling thing to strangers—one moment riding on a track from which they see another far below them; the next dashing along on the lower track, and looking upward at the one they have just left. The scene at Shepherd's Crook is one of awful grandeur. The road crosses a gorge, at the bottom of which, and 400 feet below, is the Lackawanna river. The gorge is a wilderness of primitive pine and hemlock trees, the tops of the highest of which are far below the train. In among the hemlocks a mountain stream tumbles down the mountain in a series of cataracts 300 feet in height. The Lackawanna Valley, with Carbondale and other mining places, is spread out below for miles and miles. It has been arranged for excursion trains to stop on the summit of Shepherd's Crook, to enable tourists to fully take in all the beauties of this grandest of scenery.

At Carbondale connection is made with the Delaware and Hudson Canal Company's locomotive road for Scranton and all points in the coal regions. The gravity roads have a "light" and a "loaded" track. That is, the loaded track is the one which carries the coal from the mines to the shipping places; the light track is the one on which the empty cars are carried back after new cargoes. The two roads traverse different routes to accommodate themselves to the grades and planes necessary. The Delaware and Hudson's gravity road from Carbondale to Honesdale carries the tourist up the Moosic Mountain from Carbondale by eight successive planes. Then to reach the level of Honesdale, it descends four planes, and what is called a "ten mile level," or 10 miles of track over which the cars run by their own gravity. In descending planes the cars are attached to an endless wire rope, the same as in ascending. Their speed is regulated by an immense fan at the head of the plane, the atmospheric resistance, as the fan revolves, being sufficient to control the descent of the cars to the foot of the planes. The scenery on the loaded track of the gravity road is of never-ceasing attractiveness. The Pennsylvania Coal Company's gravity railroad was constructed in 1854. It extends, really, from Pittston, Penn., to Hawley, but it is used only as far as Dunmore for passenger traffic. The scenery on this road is much wilder and more rugged than on the Honesdale road. It extends almost its entire distance through a magnificent forest, clearings and pastoral scenes being rare. Massive rock cuts, grand waterfalls, lakes as clear as crystal, weird gorges, and beetling cliffs break on the sight at every turn. Both the light and loaded tracks are 33 miles in length. There are nine planes to ascend on the trip from Hawley to Dunmore, and several long levels. The road passes Dunmore at a great height above it, runs on two miles, and "switches back" into the village. From Dunmore to Hawley the road climbs to an elevation of 2,100 feet in a distance of five miles. From that eminence the view is grand beyond description. There are six planes to ascend on the trip from Dunmore to Hawley, an uninterrupted run of 14 miles, a plane to descend, then another run of 14 miles to Hawley. The cars fairly fly along these levels, and the road is continually embowered by the forest trees. Both the Pennsylvania Coal Company's and the Canal Company's gravity roads are worked on the same system, and everything moves along like clockwork. Such a thing as an accident is so rare that it is hard for any one to remember when one has happened on either road.

## EJECTION OF PASSENGERS FROM CARS.

THE right of railroad companies to eject passengers from their cars because of non-observance of their rules and regulations, was passed upon in the case of Huertel vs. New York, etc., R. Co., decided in the State of New York, on

the 12th June. The plaintiff having a commutation ticket on the defendant's road, entered the depot and took his seat in the cars for the purpose of proceeding on his journey. The company's regulations required that passengers entering the depot should pass through a certain door. Before the train started some of the defendants' employes removed him from the car and put him out of the depot, on the ground that he had entered it by the wrong door. The plaintiff brought suit for the ejection, and obtained a verdict, which was affirmed on appeal. The court said:

"Notwithstanding the fact that the plaintiff was where he had a legal right to be at the time the defendants' employes removed him, they contend that because in getting in there he had violated a rule of the company by passing in at the wrong door, they had authority not only to prevent a violation of the rule in the first instance, but the right to punish afterwards those who succeeded in violating it by a sort of constabulary pursuit, even into the cars in which they have in the meantime become seated, and to the extent of bringing back the offender, *nolens volens*, and putting him out of the same door in which he, through mistake or indiscretion, entered, to the end that he may make a more mannerly entrance according to the company's regulations. This is altogether too tyrannical, circumlocutory and impracticable for business men seeking their homes after the day's toil, to humor or permit. While railroad companies may command obedience to such of their reasonable and orderly regulations as they have the power to enforce, they have no authority to punish by force past transgressions of such rules as they claim the plaintiff violated. * * * If a person, in an attempt to reach his own premises, trespasses upon mine, I have the undoubted right to stop him and compel him to turn back; but if he succeeds in crossing my line it must be clear that I have no right to pursue him upon his own premises and bring him back, *nolens volens*, so that he may make the entrance he ought to have made in the first instance through his own premises instead of mine. The right of pursuit ends when the person pursued reaches the place where he lawfully belongs, and if I break in upon his lawful rights at that place I become a trespasser and am answerable for whatever wrong I may commit. The right of pursuit, if it existed at all in the present case, ceased when the plaintiff got on the car, because he was lawfully there. What was done after that by the company's employes was unlawful."—*Central Law Journal.*

## BEET SUGAR IN FRANCE AND GERMANY.

By JOHN SPARROW, Portland, Me.

As there is in our community a deep interest felt for all information pertaining to our new industry, viz., of raising and extracting sugar from beets, I propose to give a short sketch of information that I have been able to gather by a three months' journey through the beet-raising districts of France and Germany, with the hope that I may be able to say something that will increase the interest among the farmers, manufacturers, and capitalists, that will insure their efforts in the line of a complete trial of the value of this industry.

I never had any pecuniary interest in the Maine Beet Sugar Co., and have none now, therefore what I may say in the interest of beets must not be marked against me as an interested party. I only write the practical facts that I have been enabled to gather with the hope that they may help in some measure to push forward faster what I truly consider will be, sooner or later, an enterprise of the first importance to our people and State, and which I hope we shall be able to claim as being the successful pioneer of this industry in our country.

In 1868 I distributed seeds of the white Silesian beet, from France and Germany, to large numbers of our farmers in different parts of the State, and received from them samples of the beets raised, which I found, by careful analysis, or test, to be equal or superior in crystallizable sugar they contained to any that we have knowledge of in any part of the world, and the average tons per acre, verified by the experience of last year, even greater. I am satisfied that both of the above results can be materially increased by experience and higher modes of cultivation. The first factory that we visited in France working green beets was situated at Meaux, twenty miles east of Paris, and here I must freely confess that on the first day, and upon the examination of the first factory, my enthusiasm and hope of ever expecting anything of the kind in Maine was dampened. It is an establishment of vast proportions, with all and every machine necessary to reduce to a minimum manual labor. This is what is called a central factory—that is, one from which radiates over fourteen miles of pipes to other localities where the juice of the beets is expressed and run through the pipes to the central works. This is to save transportation in bulk. The consumption of beets per twenty-four hours in this house is twelve hundred tons, and the product from these is from seventy to eighty tons of high quality refining sugars, testing ninety-six to ninety-seven degrees. The value of the product of this house, including the pulp and molasses, in our country, would be one million five hundred thousand dollars for the season of one hundred and twenty days.

After visiting many smaller houses which encouraged us, we passed on through Belgium into the heart of what is called the sugar district of Northern Germany. Within this district are the large cities of Braunschweig, Magdeburg, Halle, and Berlin, with considerable numbers of large towns and villages. These and all of them have their beet factories and refineries. We were in a factory at Braunschweig, which has been working continuously and profitably forty years. The Germans, although starting later, have reached and passed the French in their better machinery, size of their factories, and closer results in working. The most desirable size for factories, and those which are most found in Germany, are working one hundred, one hundred and fifty, and two hundred tons of beets per twenty-four hours. We visited a number of what are called "peasants' factories." They are on the co-operative plan—that is, owned by the farmers alone, who supply the beets and participate in the profits of the house. This system works well, and has proven very profitable, the result of which is that many of the men of Germany who started raising beets are now among the richest in the country. As with them so with us; to start a factory we want to secure from ten to twelve thousand tons of beets per annum. This amount of beets will require five hundred and fifty acres of land all put down to beets. Then, as rotation of crops is universal, that is, they only employ the same lands for beets once in four years, this will necessitate the cultivation of two thousand to twenty-four hundred acres of land to supply one factory using one hundred tons per day, for the season. This can be done, and only done, by a great number of small farmers taking hold of the business with spirit, and it seems to me not a very great task to accomplish. All our lands are good for beets, if for anything, and all that is required is thorough and intelligent cultivation. We have been on lands that have been down to beets every four years for the last fifty years, and yet they don't refuse to give good results.

Some idea of the vast importance of this industry to Northern Germany may be had, when I state (and that from the most reliable authority) that the number of acres put down to beets for the season of 1878 has been 400,000. Beets raised upon this land are 4,500,000 tons, and the sugar estimated is 450,000 tons, or 900,000,000 pounds, and the sugar, molasses, and pulp is valued at $63,000,000.

The price paid to the farmer for beets delivered at the factory or railroad is $5.00 per ton with the crowns cut off, and less 6 per cent. of weight for earth. The factory also pays to the government the excise tax of $4.00 per ton. The beets, after being washed and prepared for the mill, are weighed by a government officer, who has an office and scales in every factory. The scales are very ingeniously arranged, self-registering, and a check upon the honesty or dishonesty of the official This seeming high price for beets is somewhat modified by the drawback allowed on sugars exported, which is about the excise tax, less 10 per cent. for custom expenses.

In this country there is no excise tax on beets; on the contrary, and in favor of the factory, we have a protective duty from 1¾ to 4½ cents per pound on the class of sugars that we are able to make from beets. In view of these facts, I am satisfied that the Beet Company can offer a much higher price to the farmers for good beets than that of last year. The farmers labor under the disadvantage of inexperience in the best and cheapest mode of cultivating the beet, and, until further advanced in this line, must be encouraged by the factories at some risk by receiving the highest possible prices for their beets.

The true and great value of this industry will not be seen until all the conditions connected with it, from the farmer to the factory, are observed and complied with. The farmer raising beets should have sheep to forage upon the leaves and refuse beets at harvest time; and if, within carting distance of the factory, he will not neglect the pulp, which, if well prepared, is worth $3.00 per ton as fodder for cattle. We saw cattle doing the fall plowing, which were fed upon the pulp and one-third chopped straw and a little meal, that looked as well, and were doing as good work, as any that I have seen in Maine. In none of the factories of Germany did we see an accumulation of pulp. It was sought for and taken away as fast as made by the farmers. There are some houses that keep from 50 to 100 head of cattle, which are fed chiefly upon pulp and straw, and made fat in 90 to 100 days fit for the market.

The quantity of water in beet roots varies from 83 to 88 per cent. But beet root pulp, which is 20 per cent. of the weight of beets, after it has been pressed, has the same value as the original root which produced it, weight for weight; so that its price may readily be established on the basis of 4½ pounds of pulp, being the equivalent of one pound of hay, or 100 pounds of pulp equal to 22 pounds good hay. If 20 tons of beets are raised to the acre, and if the weight of pulp averages 18 per cent. of that of the beets, we find 8,064 pounds of pulp (equal to 1,774 pounds of hay) to the acre, to be available for the purpose of feeding or fattening live stock. It is estimated that in growing and harvesting one acre of beets requires 46 days of human (partly children) and 14 days of horse labor. In the West Indies one acre of sugar cane necessitates 172 days of human labor.

The machinery of these factories is nearly perfect. It takes the beet in the beet house upon its carrier, washes it, weighs it, slices it, and delivers it to the diffusion vessels, then through all the ramifications of the refining process; and finally it is delivered from the vacuum pans crystals of sugar. The whole operation makes as fine an exhibition of the power of mind over matter as one can possibly conceive.

### PREPARING THE LAND.

Deep plowing and thorough cultivation of the soil is absolutely necessary. Farmers commence this work immediately after harvest, plowing deep, cross-plowing and harrowing.

### ROTATION OF CROPS IS UNIVERSAL.

That is, beets are grown upon the same land but once in four years. Raw manures are not used on the land designed for beets this year, for the reason that they generate more weeds than the patent manures. They use fertilizers to a large extent, which contain a large amount of phosphate of lime.

### PLANTING.

The furrows are about 18 to 20 inches apart, and the drill drops the seed 8 to 10 inches apart. The object in having the roots so near together is to get smaller beets, which are richer in sugar and more easily kept covered, and the weight per acre is even more than of larger beets.

### CULTIVATION.

The beets make their appearance in from 10 to 12 days, and when large enough to distinguish from the weeds, is the time when the full energy and industry of the farmer is to be employed. The weeds must be warred upon at once, and kept down, and if any seeds have not germinated, transplanting must be done to make up the deficiency. A cultivator and horse is used in the furrows, and hoe and hand weeding between the roots. After the first, second, and third weeding the work lessens, and the cultivation is made comparatively easy. The roots must be kept well covered, as the crown, or that above the ground, is not rich in sugar, and hence is rejected by the manufacturer.

### HARVESTING.

Some use a plow, which is dangerous without the most careful handling. A careless hand will bruise the beets, and such are not satisfactory to the purchaser. By others the earth is loosened with a narrow spade, the root pulled by hand and laid upon the ground. The trimming is done by some with a curved knife with a long handle, while the beet is on the ground; others take the beet in hand, and with a heavy knife sever the crown from the top, and pass the beets into carts. The crown and leaves are utilized by farmers as food for stock.

### PRESERVATION OF BEETS.

Factories using 10, 15, and 20,000 tons of beets in a season cannot receive more than fifty per cent. of the crop during harvesting. The balance has to be protected for winter use, which is done in silos or pits. The pits are made by digging down in the earth two feet deep by twelve or fourteen feet wide, and of any length, leaving the center of the floor a little the highest to afford drainage. The beets are then laid in and a wall made of them, inclining inward at the rate of about one foot in three. When the pile is laid to the height of six or seven feet, the whole is covered with earth well patted, to protect them as much as possible from air and frost. The usual method in Europe is to contract with each farmer for the delivery of his beets throughout the season. The best method of preserving the beet is to keep it continually frozen, for freezing does not injure its saccharine properties, but it facilitates the extraction of sugar, probably because frost ruptures the sap vessels more completely than it is possible to do mechanically. In this we are much favored by climate, as our continuous cold weather would enable us to preserve our beets so as to extend our working season well into April or May. The preserving need not disturb us for at least two or three years, nor until there are beets enough raised to supply a factory working one hundred and fifty or two hundred tons per day, over three months. Then, and not until then, the art of preserving need be practiced.

### ADVANTAGES OF BEET RAISING.

Some of the advantages that would accrue to the State and people by the introduction of this industry are: *First*, To induce your young men to remain among us, by giving them in summer employment as agriculturists, and in winter an opportunity of becoming skilled workmen in the manipulations of the machinery of a refinery and science of chemistry. *Second*, of retaining the value of all the products in the State, as there is nothing required but that we can furnish, with the exception of fuel, and that, even, in some localities may be partially supplied. *Third*, the power for cattle raising could be increased a thousand fold. *Fourth*, the farmer can raise his crop of beets as gold, because a railroad or factory certificate of delivery will always command it. The price of beets will never be less, possibly more. His acres of beets will net him more than any other crop, and then, when it is known we can raise more than is necessary for one factory, the farmers will have co-operative factories, and participate in their success.

An English scientist and careful observer of crops and seasons affirms, that with a thirty years' record he finds that man's efforts, with all his knowledge of agriculture, and the use of all appliances and manures in the cultivation of crops, with his industry and constant attention, can only be marked as one for success, whereas to a Providence or the season he accords four parts for good or ill results. This holds good in regard to all crops, and shows man's dependence upon sun, rain, dry and seasonable weather in their turn, for all his successes and final prosperity. This, he holds, has been the experience of all from the foundation of the world to the present time, and is the inevitable for the future. The German says that with all man can do he must still rely upon God, and God only, who makes the sugar in the beets and wine in the grapes, and made man with intelligence to extract them.

There is no industry of Germany which ought to interest the United States so much as the production of sugar from the beet root. The United States (more especially the Eastern and Northern) seems to me to be in every respect as well, and, in many respects, much better adapted for its production than Germany or France. Beets containing a large amount of saccharine matter can be abundantly and cheaply raised, and if the great profit of converting them into sugar was fully understood, there would be plenty of capital for the supply of the necessary machinery.

The machinery is expensive, and it requires a large amount of capital to commence operations, but it is doubtful whether there is any branch of industry which would so well repay capital and enterprise. The business cannot well be conducted on a small scale, and this disadvantage has doubtless hitherto prevented its being generally adopted in the United States. But when it shall have been given a fair trial it must become a very important interest.

In locating and establishing a factory, there are certain conditions and considerations that must be observed, and abuses and evils that have heretofore attended our inexperienced trials avoided. A location on a line of railroad is very desirable, and an abundance of cheap water absolutely necessary. The highest quality of machinery should be selected, and that, managed by known experts in the business, will insure satisfactory results; on the contrary, poor and inefficient machinery, worked by merely amateur sugar makers, will prove, as it always has, disastrous. We made arrangements with the best known manufacturers of Germany and France for any supply of machinery that we may require. But the whole, with the exception possibly of a few machines, can be made here as well, by any of our good machine shops, as there, under proper instructions.

The only question to settle is, can we import machinery, with the advantage of duty free, cheaper than we can manufacture it in this country? The price of machinery in Germany is cheaper than here. But when we add the cost of transportation, insurance, and loss of time, as an interest account, I am convinced that at least three-quarters of the full armature of a complete beet factory can and must be made here. The importance of securing the best machinery, and the most experienced talent to work it, cannot be overstated.

The high state of success and prosperity to which this industry has arrived, is due and has only been accomplished by the combined efforts of the best and highest mechanical and chemical knowledge constantly at work for the last forty years, and it would be worse than folly to pretend to experiment, when we have the privilege of transplanting in our country that which would be a complete success from the beginning.

In 1747 Magraff and Achard discovered that beets contained sugar, and that 3 to 4 per cent. of sugar would warrant the prosecution of the industry. We may judge of its importance and advance when in 1867 and 1868 the yield reached 8 per cent., and in 1877 and 1878 it was 9 and 10 per cent., and I have no doubt but that, with the best of beets and close working, a much higher yield may be obtained, and even 12 to 14 per cent. is not too high to be expected and realized. I consider it not wild or visionary to state that in five years Maine should be able to supply herself with sugar, and a surplus for export. In Germany 32 of these factories were built in one year.

Much credit is due to the gentlemen of the Maine Beet Sugar Company for their courage, industry, and generous outlay in the enterprise last year, and so confident are they of final success, that they are making ample arrangements for a large production this year. They made last year 180,000 pounds of white sugar; this year, with the generous aid of the farmers, an average crop, and addition of improved machinery, they hope to make 1,500 tons, or 3,000,-

000 pounds. If successful in this, the thing is accomplished, and our new industry established. Ten factories would supply our wants, and something over.

You should bear in mind that you are not merely working for an individual or company, but that you are demonstrating a principle or fact which, in my judgment, will eventually turn to your great advantage. The Germans think that Providence has done more for us than we have improved or done for ourselves, that is, that we are not making the best of our opportunities, and, if they had but a part of our lands, they would raise sugar to supply the world. Napoleon said, speaking of beets: "Respect me, for I improve the soil; I make land fertile which, without me, would be uncultivated; I give employment to laborers, who otherwise would be idle; I solve one of the greatest problems of society; I organize and elevate labor."—*Maine Farmer.*

## FOOD, PHYSIOLOGY, AND FORCE.*

By DR. E. L. STURTEVANT, Framingham, Mass.

COULD we trace back the milk in a cow's udder to its previous conditions before it became milk, or if this process could take place in regard to either of the constituents which in their combination go in their entirety to make milk, we would recognize each constituent as formed from or through some other condition or substance through the expenditure of force. Should the same process of investigation be continued, it would be seen that one state of matter could be referred back to other states of matter more or less complex, until finally all the various steps would be seen to originate in turn from a force originally received from without.

It is thus that the science of physics and physiology must be combined, in order to rightly understand the animal functions and animal products.

What is food? It is but a form of force, or product derived from the forces of the universe, which have been segregated and stored into a form which can be made to give up their power to an animal.

What is the animal? It is the product of force or forces, just as is the food; for one animal may serve as food for another. The animal can but liberate the forces from its food, and utilize a certain portion in animal heat, motion, product, etc. It can no more generate force than can a steam engine perform work without fuel.

Work is the term used to express the energy of a force. In a valuable little treatise by Balfour Stewart (The Conservation of Energy), we are told how to measure work. He says: "We have defined energy to be the power of doing work; and although every one has a general notion of what is meant by work, that notion may not be sufficiently precise for the purpose of this volume. How, then, are we to measure work? . . . There is a force at hand which enables us to accomplish this measurement with the greatest precision; and this force is gravity."

If we raise a pound weight one foot high, we are conscious of having put forth an effort; and this work performed we will call a foot pound. Now whether we lift one hundred pounds to the vertical height of one foot, or whether we lift one pound to the vertical height of one hundred feet, we have expended the same amount of energy. This foot pound is the unit by which we can adapt gravity to our purpose, just as the yard stick is the unit by which our ideas of extension are localized.

That this idea of work and force may be better apprehended, let us examine into the amount of force which can be obtained from various articles of food; for, as we have seen, we have a method of expressing their energies in a mechanical form.

Our table expresses simply the total mechanical work which the combustion in the body of one pound of each food is capable of producing outside of the body, supposing its effect to be *wholly* expended in the production of this mechanical work without any waste. Moreover, this statement of the amount of work in tons lifted one foot does not take *time* at all into account. It simply reckons the total work which it is possible to get out of the combustion of one pound of the substance, no matter how long it may take to do it.

| Name of Food. | Tons Raised One Foot High. |
|---|---|
| Cod liver oil | 5,649 |
| Beef fat | 5,626 |
| Butter | 4,507 |
| Cheshire cheese | 2,704 |
| Oatmeal | 2,439 |
| Flour | 2,383 |
| Lean of beef | 885 |
| Potatoes | 618 |
| Milk | 390 |
| Carrots | 322 |
| Cabbage | 261 |

The maximum amount of mechanical work which one pound of each of the above substances can enable a man to perform (external work) is about one-fifth of the amount mentioned in the above table. (Ken. Mus. Invent. of Food Col., Lond., 1869, p. 46.)

We have now definitely expressed one difference in the values which we all know appertain to different foods.

Should we place wet and soggy fuel under our steam boiler, and an equivalent amount of dry fuel under another, we should find the amount of steam generated to be different in either case. Perhaps the conditions are alike as regards the boilers, and the amount of heat liberated by the fuel under each boiler may be the same in either instance. How, then, account for the difference in the results which practice tells us always occurs? In the one case, the fuel being dry, the whole force let loose by the chemistry of combustion is available for the purpose of heating; in the case of the wet fuel, a portion of this force is utilized in vaporizing the water in the fuel, leaving less heat available for the generation of the steam in the boiler. We have thus an explanation of a seeming discrepancy, in a very simple case, where we have to consider but a few elements. In the animal and the food, however, we have more complex issues: the food, a variable product, not only in the total of its pent-up forces, but also in the manner of their combustion; the animal, with a varying power for unlocking these forces and appropriating the same to his uses.

What wonder, then, that in this complexity of phenomena the physiologist should often be unable to arrive at exact results in individual cases? It is too often that science is discredited, because, although powerful in dealing with groups, it is unable to follow out the idiosyncrasies of the individual. In the domain of physical science we know much with exactness; we deal with the motions of the universe, and predict eclipses; we deal with the science of mechanics, calculate resistance, and construct machines with a known power for a known purpose; we form the curves of our ships by means of studied formulas; and turn matter at will to the purposes of our pleasure or profit, by efforts calculated with exactness, predicated upon known laws, and verified by results. Yet we know not the properties of the single molecule of matter, nor can we even recognize the structure of the individual atom.

The weight of the body is the equilibrium between the materials ingested and those which are egested, ingestion being dependent on absorption and nutrition, egestion on the uses and wastes. Whenever the balance between these terms is disturbed, we have a gain or loss in weight.

A certain amount of nutriment is needed for the support of the body, because the body utilizes forces and converts them into other states of matter, as heat, motion, and substance. Nutrition is but the supply of fresh force in a convertible and available form.

A wisp of hay is swallowed by a cow, and immediately the forces already stored in the animal's body in various forms commence to act upon it, and draw from it the forces which it contains. One portion of this force is utilized in the respiration and circulation, another in the products, and a portion, it may be, in storing provision for future needs.

What is the object of the respiration and circulation? The force of the wood is developed by the action of oxygen. When a piece of wood is set on fire in the air, the particles of oxygen rush upon the wood, and, uniting with it, produce the phenomena of heat and flame, while the new formations, the carbonic oxides, are dissipated in the air.

When wood decays, the same process is going on, but so much slower, that it is not accompanied by flame. In either case, whether swift or slow, the same amount of force is developed, and the same process takes place. Now heat is the equivalent of the forces produced by oxidation, wherever it occurs, and animal heat is no exception to this law. By the wonderful adaptation of animal structure, the oxygen is supplied to the body to maintain its heat through the agency of the circulation and respiration.

The air, which is composed of an intimate mixture of nitrogen and oxygen, by the movement of respiration is inhaled within the lungs, a curious tissue filled with blood vessels, through which the whole blood of the body passes in turn. The blood is a fluid containing innumerable globules, or disks, about one-four thousandth inch in diameter in the cow, and which are colored by a compound of iron and albumen. This coloring matter (globuline) has the remarkable property of absorbing oxygen when exposed to the air, and of giving it out again in the presence of reducing agents.

The heart, by its contraction, forces the blood to and through the blood vessels of the lungs, when it is separated from the inspired air, but by thin and permeable tissues; the blood disks each seize upon these particles of oxygen, and at the same time part with the carbonic acid which they have taken up in their course. These blood disks then circulate into all portions of the body, carrying their loads of oxygen, which, in the appropriate place, unites with the carbon, liberating carbonic acid, which again, in due course, is discharged through the lungs. The blood, on its way to the lungs with its load of carbon, is known as venous blood, and is dark in color; after having given out its carbon and received its new supply of oxygen, it takes on a bright color, and is known as arterial blood.

It is thus seen that the process which supports the animal heat is in effect combustion, and can be likened to the burning of wood or coal. As it is well known that the animal body partakes of the surrounding temperature, if supplies of fuel (food) are cut off, in no wise different from inanimate matter, which, indeed, it becomes under these circumstances, we are justified in affirming that it is only by the expenditure of force, that is, food, that the heat of the body is supported. Such being the fact, we realize the importance of shelter and warmth to an animal in economizing its food.

Perhaps we do not fully realize the effect of even small changes on the amount of food consumed. We find there is force consumed even in the matter of standing or walking. How much more, then, in the efforts to overcome the cooling influence of external temperature! We will put in a tabular form some results obtained by Dr. Edward Smith, who ascertained, by direct experiment, that the amount of carbonic acid exhaled by the lungs in man was in proportion to the actual work performed.

During sleep, at rate of 293 grains per hour, or at rate of 4·4 ounces carbon daily.

Lying, approaching sleep, 355 grains per hour, or at rate of 5·2 ounces carbon daily.

In a sitting posture, 491 grains per hour, or at rate of 7·3 ounces carbon daily.

Walking two miles an hour, 1,088 grains per hour, or at rate of 16·2 ounces carbon daily.

Walking three miles an hour, 1,552 grains per hour, or at rate of 23·2 ounces carbon daily.

Working at treadmill, 2,926 grains per hour, or at rate of 43·7 ounces carbon daily.

Now the amount of carbon is an exact measure of the force expended in the respiratory and circulating processes; and although our figures mean little by themselves, as a man cannot sleep or work in the treadmill the whole of every twenty-four hours, yet they do indicate the changes in the amount of food which must be ingested in order to furnish force for the purpose of labor. As a matter of fact, the average amount of carbon (charcoal) exhaled from the lungs of a healthy man may be placed at about 8½ ounces daily.

As we know so little of the minute details of the utilization of the food by the cow, it will be useless to discuss by figures which pretend to be accurate, without having the scientific essential of accurate foundations. What we can do, however, is to lay down general principles whose truths are undeniable; and this one, of force as connected with physiology, is essential even to the practical farmer.

The force which is received through one wisp of hay gives a large proportion toward sustaining the respiration and circulation. That we may form an idea of the amount required for this work, we will use analogy: for, in the case of man, we have had accurate experimentation and study. Now, in man, each beat of the heart is estimated as equal to a lift of 4·63 pounds one foot high; and it is considered, from Donders' well known investigations, that the work of respiration is nearly the same: namely, 4·56 pounds a foot high. (Letheby.) If we multiply these figures by 70 and 20 respectively, the average number of beats of the heart and of the respirations per minute according to Flint, we have the labor for one minute expressed in foot pounds; multiplying again by the number of minutes in the day of twenty-four hours, we have the total amount of labor performed daily, in foot pounds, for these purposes. Now, a cow is six times as heavy as a man, and it is probable that multiplying the results we have obtained by six would give a result not so very far out of the way for the cow.

It is undeniably true, if our premises are right, that the actual amount of labor expended will vary with the size of the animal; that the larger cow will use up a larger amount of the force in the food for those purposes connected with life than will a smaller cow; and that the difference, if carefully studied, would be appreciable.

A state of activity is one which develops an increased temperature, and an increase of temperature, as well as the maintenance of temperature, means an increase of food. Thus it is stated (Clatus Cattle Doctor, Armatage) that the normal temperature of the cow at rest is 100·8°, and at liberty 101·8°. Whatever increases the rapidity of the circulation, also increases the work done—if not necessarily, yet as a matter of practice.

Thus, from the experiment of Hering, it was shown that in the horse, when the heart was beating at the rate of 36 per minute with eight respiratory acts, ferro-cyanide of potassium injected into the jugular appeared in the vessel on the opposite side after an interval of from 20 to 25 seconds. When the pulsation of the heart was increased by exercise to 100 per minute, the circulation was accomplished in from 15 to 20 seconds.

Now, the labor performed in circulating and creating the blood of the man is nearly 600,000 foot pounds daily according to our calculation. If we should apply the same figures to the results obtained from the horse, we should have—

Pulse 36, 8 respiratory acts, daily work 292,550 ft. lb.
Pulse 100, 20 " " " " 798,048 " "

However, as the horse is six times, at least, the bulk of the man, these figures must be multiplied by six to give us the proper figures. We therefore have for the corrected result:

Pulse 36, respiratory acts 8, daily work 1,755,300 ft. lb.
Pulse 100, " " 20, " " 4,788,288 " "

Or, assuming that we are feeding carrots, from which the complete thermetic force is attainable, it would take three pounds in the first case, and seven pounds in the other, to furnish the force necessary under the different conditions.

In like manner, we could estimate the amount of force required to support the temperature of the body under diverse conditions of external temperature. We need only say, however, that the mechanical equivalent of the force required to raise one pound of water one degree in temperature is 772 foot pounds.

We have now illustrated the general principle that the vital actions of the body constitute work, and their forces utilized have to be supplied by food. It is an important question to the farmer whether his cows climb hills, or chase around the pastures, or winter in open barns, and the like; although we have made no definite attempt to give the absolute values of the difference in figures. In the case of man, the absolute work performed is usually about one-fifth of the thermetic power of his food; and, according to Professor Houghton, about three-quarters of the food of a working man of 150 pounds weight is used in merely keeping him alive; the remaining fourth is expended in the production of mechanical force, constituting his daily toil. It is plain, as has been established by accidental trials, that it is an economy to feed the workman beyond the absolute needs of the body for supporting life, as it is only after a certain limit that the profits commence to be derived. Let the farmer apply these principles to the feeding of the animals under his charge. The last food pays best.

Nitrogenous foods and the supply of waste tissues is a subject which I shall not dwell upon, as it involves a larger discussion than I feel inclined to indulge in in this paper. The supply of nitrogen in the food, and the amount of nitrogen in the excretions, have much to do with the question of foods. The nitrogenous portions of the food are fitted for building up flesh, and have to be in a certain proportion to the other elements. Like all other elements of the food, the particular form in which nitrogen occurs has much to do with its usefulness. According to Letheby, the glutinous matters of barley and wheat have very different sustaining powers.

We have various other functions of the force producers stored in the food, and the disposal of them has various differences. Thus, the nitrogenous matters, in their passage from the system as urea, lose much of the actual energy in their potential energy. The forces of the starch ingredients and the sugar may, by a process of transformation, be stored as fat, a deposit not only for present convenience, but also a supply against future needs of the respiratory system. In cases of starvation, we find that the fat disappears in the largest degree of any of the tissues, illustrating the importance of respiratory forces.

In the products we shall consider but one, and that shortly, the milk. This is a fluid designed for the nourishment of the young animal, and contains not only the forces designed for the support of life—respiratory—but also those other materials required for the building up of the frame and body.

One pound of milk, when digested and oxidized in the body, is capable of producing, at the maximum, a force equal to 390 tons raised one foot high, and can produce, at the maximum, 8–10 of an ounce of dry muscle or flesh.

That we may bring the value of milk more fully before us, we will compare it with meat.

One pound of the lean of beef is capable of producing an amount of force equal to 885 tons raised one foot high, and, at the maximum, will produce 2½ ounces of dry muscle or flesh.

One pound of beef fat contains a mechanical force equivalent to 5,626 foot tons, but it produces no flesh or muscle.

One pound of lean beef, as a force producer, is equal to 2·27 pounds of milk.

One pound of lean beef, as a flesh producer, is equal to 2·09 pounds of milk.

Beef, however, notwithstanding the cut, will necessarily contain more or less fat. We will, therefore, bring together analyses of the two substances:

| | Beef. | Milk. |
|---|---|---|
| Water | 50 | 86·00 |
| Solids | 50 | 14·00 |
| Fat | 30 | 3·5 |
| Albumen | 8 | 5·00 |
| Gelatine | 7 | 0 |
| Sugar | 0 | 4·5 |
| Salts | 5 | 1·00 |

From this analysis, we again derive an idea of the relative importance of milk.

* From Fourth Annual Report of New Hampshire Board of Agriculture.

Now this fluid, so agreeable to the taste and so nutritive, cannot be derived from nothing. In fact it contains, as we have seen, a large amount of force, that is, food, and every particle of milk yielded by the cow must of necessity have entered her body at some time as food. If we bear, then, in mind that product can only be derived from product, and these products all represent forces, and that these forces can all be dissipated in various ways, it will be seen how ignorant is the man, not to say dishonest, who claims to attain a large product on insufficient feed.

It will also be seen how unwise it is to turn these forces from their profitable function of product (either milk, fat, or growth) towards supplying the deficiency of knowledge on the part of the owner. When an animal is exposed to the cold wintry blasts, she is being compelled, as it were, by her owner, to consume more food, and this food is largely wasted in keeping up a temperature which is being lessened by such cruel neglect. As a rule, protection is a cheaper fuel than corn or hay.

Again: it will be seen that certain forces are necessary for the support of the body. These forces have to be supplied by the food, and it is only as the food exceeds this minimum that the profit commences. The unwisdom of under-feeding is thus seen. With the rightly constituted animal which digests her food, every additional mouthful of food she can be persuaded to digest is a source of increasing profit to her owner.

As all the animal motions result from forces, and are the products of food, it will again be perceived how unwise is the harassing of cattle unnecessarily, whether by dogs or children.

As forces are required for animal progression, and as the whole weight of the cow has to be lifted up every step, in whatever way the hill be surmounted, it will be perceived that a true economy would dictate the size of the animal best adapted to the pasture. Of two cows, equally good milkers, the larger must consume more of her food in sustaining the increased exertion of carrying her greater weight in the roaming for feed than the smaller cow, and, therefore, in this one respect, would be indicated as being less profitable to her owner.

## ADULTERATION OF TEA.

DR. J. M. EDER is the authority for the statement that one-half of all the tea sold is mixed with spent tea leaves. Processes for the sophistication of tea are considered valuable property, and if there has not been some misinformation sent abroad, the owner of a tea-doctoring secret lately sought protection in its use from our courts. Among dealers of an article so generally used as tea there is a keen competition, and the temptation to have recourse to swindling as a fine art is strong and sometimes irresistible. By and by the evils will compel a remedy. There are few subjects that are bet ter worth the energetic attention of officers intrusted with the public health than the extent and kind of tea adulteration. Exhausted leaves are not the worst substances employed. Dr. Eder sets no value on the determination of theine as a test of the character of tea. He proposes to ascertain the total extractive matter as obtained with hot water, the proportion of tannin in the solution, the total amount of ash, and the proportion of ash soluble in water.

## THE AUTOPSY OF AN ELEPHANT.

By A. J. HOWE, M.D.

THE day before last Christmas John Robinson lost by death one of the largest specimens of his fine herd of elephants. The animal bore the name of "Conqueror," and originally came from Abyssinia. He had been in America fifteen years.

Conqueror was so fond of fun that he would in his way challenge boys to throw stones at him, and if he succeeded in cajoling them into a contest of the kind he would gather the missiles that hit his sides and fell to the ground, until he had quite a supply upon which to draw when he chose to hurl the ammunition back. It seemed to give the ponderous pachyderm great delight as the boys scattered with a shout when a stone fell in their midst.

At length Mr. Robinson placed Conqueror in company with seven or eight other elephants, and took him about the country as a feature of his traveling menagerie; but the playful nature of the beast so often gave way to fits of anger that he proved an unwelcome part of the "show." He took the conceit that he would not obey any one except his old master, and came near killing two or three men who undertook to exercise authority over him; and he often provoked quarrels with the other elephants, and attempted to stampede the camels, dromedaries, and other animals of any significance in his estimation. He seemed to covet a contest with the larger felines, especially the tigers, against whom he appeared to entertain an instinctive hate. These caprices and freaks of temper caused him to be hampered with chains that extended around his body, over his tusks, and to bracelets locked upon his wrists. These incumbrances made him so irritable while traveling on a fenced platform car, on the railroad, that he made a desperate attempt to break loose while the train was in motion. In this struggle one fore-foot was so much bruised that the animal had to be taken to a quiet retreat for recuperation. Three months afterwards the foot had so far recovered that Conqueror went into winter quarters with his old companions, and seemed pleased to return to the company of his fellow kind. However, he could not live in peace with anybody—he must play or quarrel, so exuberant were his spirits. His companions could stand a certain amount of his rude frolics, but at length they would unite their forces and drive him to his corner of the inclosure, where he would utter the well-known bellow of submission. After patching up a truce he might be quite companionable for a few days, until his restless spirit provoked a fresh onset. His inclination ran chiefly to badgering the four Indian elephants in the corral with him; and they at length, after forbearance ceased to be a virtue, made a fierce onslaught upon the ill-mannered African, and so severely punished him with thrusts of their tusks in his neck and shoulder that a large vein was lacerated, and Conqueror cried "hold, enough!" for the last time. In two days he was dead, and his carcass became the property of the Cincinnati Society of Natural History. Our taxidermist, Charles Dury, with a force of assistants, proceeded with zeal to flay the monster, and to preserve the skin and skeleton. The dissection lasted several days; and during the time I endeavored to investigate the organic peculiarities of this massive specimen of the animal kingdom.

It was estimated that the entire elephant weighed more than five thousand pounds, and that the skin, with some fat and fascia attached, would weigh over eight hundred pounds. The integument was comparatively thin on the inside of the legs and under side of the abdomen, but on the back and exposed parts of the creature the skin was more than an inch thick. Surely the animal is entitled to be called a "pachyderm."

The prominent peculiarities of the African elephant are his untamable disposition, his prominently convex forehead, his immensely large ears, and sloping or receding rump. Although the "African" elephant was employed by the Carthagenians in their wars with the Romans and the rest of mankind, the art of capturing and taming the creature was lost to the inhabitants of the Middle Ages. It is not long since the African elephants were placed in the London Zoological Gardens. The ivory of the African elephant is more valuable than that of the Asiatic species, hence it is sought by every trader doing business in the "dark continent." It has been estimated that seventy-five thousand African elephants are annually slain for the tusks alone; and when guns of large caliber are distributed among the native Africans from the Sahara desert to Cape Colony, the elephant will become extinct, or exceedingly scarce. The trunk or proboscis of the elephant is a curious appendage to the upper lip and nose. The attachment to the forehead is through powerful muscles, ligaments, and fascias. The implement contains enough dense structure to render it manageable, and it is sufficiently flexible for the multiple purposes executed by the organ. The free end of the trunk has a finger or thumb like extension that is capable of picking up a straw or even a pin. Inasmuch as the elephant obtains its food and drink through the instrumentality of the proboscis, it is not strange that the animal guards the useful organ against all harm. When the huge proboscidian is attacked by the tiger, its inveterate foe, the trunk is raised high in the air, and the tusks are employed to toss the great feline. On the other hand, the tiger understands the vulnerable part of the elephant, and seeks an opportunity to leap upon the forehead at the base of the tusks, and there, with tooth and nail, inflict direful wounds upon its clumsy enemy.

An elephant's proboscis is really a prolonged upper lip and snout, the nasal chambers running the entire length of the organ, and directly connecting with nasal apertures in the skull of the animal. A dense vomerine septum divides the chambers in the proboscis, and connects with the osseous vomer of the facial bones. Near the junction of the trunk with the skull there is a valvular arrangement in the nasal chambers which is of use in sucking fluids and fine substances into the proboscis, which are afterward to be discharged into the mouth or outwardly by means of air expressed from the lungs. The creature uses the trunk thus to spurt water upon its back and sides when inclined to enjoy the luxury of a shower bath.

The tusks of the elephant are a distinguishing feature of the creature. They spring from the premaxillary bones, hence are modifications of incisor teeth. They correspond to the gnawing teeth of the beaver and other rod ents. The extinct mammoth had two others which sprang from the lower jaw and projected forward. The dugong has two in the inferior maxillary which curve downward as the tusks of the elephant incline to turn upward. The tusks of the elephant are largest in the male, and are used as weapons, yet they become useful in breaking down branches and in uprooting small trees while food is gathered.

The grinders of the elephant are compound teeth, having ridges of dentine on their bruising surfaces. Representatively there is but one grinder in each side of either jaw. The tooth springs from the alveolar space in the deep and posterior recesses of the maxillaries, and while growing or developing moves forward, and its anterior thin edge breaks off, so that in the course of several years the entire grinder is lost; but before it is half wasted another comes along in the rear and occupies the same place and position of the one passing away. In this replacing process it is not uncommon for an entire tooth and part of another to be present in one side of a jaw at the same time. In several respects the dentition of the elephant is peculiar.

The under jaw of the extinct mastodon, mammoth, and living elephant have a deep notch in the front aspect of the under jaw, through which it would seem a long and free tongue protruded for the purpose of gathering herbage, but the real fact of the case is, that the elephant has a restricted use of the tongue, the tapering and conical end being free to a limited extent. It has been said that the elephant is tongue-tied; also that it has no frænum linguæ, and is consequently free-tongued, but neither state really exists.

The pharynx of the elephant is capacious, and, as in the ox, terminates in the œsophagus, with the bulbous larynx projecting into it. The posterior nares extend into the pharynx, but with a direction and extension which make them almost communicate with the larynx. At the upper part of the pharynx is a pocket, in which, at a central point, terminates a single canal that soon, by division and subdivision, communicates with the extensive sinuses and air-cells in the forehead and other parts of the skull.

The larynx of the elephant is very large, and bears the general features of the same organ in the horse. The trachea is a complete tube, the rings, thirty in number, coming together, though not joining, on the œsophageal surface, where in a man there exists an interposing membrane. When the elephant utters its loudest voice the sound resembles that coming from a trumpet. The lungs have no lobes, but a process of pulmonary tissue extends between the heart and diaphragm. The stomach of the elephant is thrown into ridges or partial compartments by muscular bands that nearly encircle the organ. One of these compartments at the extreme left of the organ can be made to hold water unmixed with food—an arrangement somewhat like that of a camel. The lining membrane of the stomach is coarsely plicated; and sometimes the folds join, making cups or circumscribed spaces. The organ will hold five or six bushels, and probably much more when distended to its fullest capacity. The jejunum is eight inches in diameter, and receives the biliary and pancreatic secretions in receptacles or pouches situated a short distance below the stomach. The liver has two lobes, divided by the suspensory ligament, but no gall bladder. The cæcum is large, with its inner surface rugous. The colon is about twenty feet in length and a foot in diameter. The entire alimentary track is more than sixty feet long. The fæces are discharged in lumps or balls when the animal feeds upon hay, but present a mushy consistence when meal, grain, and fruits make up a large part of the animal's diet.

The circulatory system of the elephant is like that of most mammals. The heart is a foot or more in diameter, and in its contraction exerts tons of pressure. The aorta is over three inches in diameter, and its walls are thick with yellow elastic tissue. The current of blood propelled at each stroke of the heart must equal that forced from the nozzle of a steam fire engine. The veins have thick walls, and correspond in caliber with companion arteries. The testes of the elephant never descend into a tegumentary scrotum, but remain in a fold of peritoneum just below the kidneys. In this respect the creature approaches birds and reptiles. The testes of the rhinoceros descend to the internal abdominal ring, and there remain through life.

The female elephant has two mammary glands located between the fore legs. The young elephant sucks the teats with its lips. The period of gestation peculiar to the elephant extends through a period of over five hundred days, or nearly two years. These great proboscidians rarely breed in captivity. Some years ago the birth of an elephant took place in the Zoological Gardens in London; and one is to take place in America within a few months, conception having taken place on the 25th of May, 1878, at Concord, N. H., the pairing having occurred in the "Great London Circus." The conjunction was like that between equines or bovines, by mounting.

The eye of the elephant is comparatively small, the organ being but a little larger than it is in the horse. The sclerotic tunic is very dense, and the fascias which bind the eye in the orbit are thick and tough.

The external ear of the African elephant is exceedingly large and leathery. In fact, the size of the ear is one of the characteristic features of the species. Muscles keep the auricles in flapping motion, especially when flies or other insects are to be driven away. The external auditory passages, as well as the fluted conchas, are freely exposed outwardly, and not covered by the overlapping auricle, as in animals with drooping ears. The hearing of the elephant is very acute, as well as the sense of sight. The membrana tympani is a complete oval, and seems to send fibers from its center, where the handle of the malleus rests, to the circumference with regular radiation.

The ligamentum nuchæ of the elephant is the thickest and strongest band of elastic tissue to be found in the animal kingdom. Specimen disks of this structure were saved; some of them measured from eight to ten inches in circumference. The ligament must be immensely strong to sustain the ponderous head. The muscles which move the head and under jaw are large, coarse, and terribly tough. The tendinous intersection would turn the edge of the best knives.

The brain of the elephant is larger than that of man, and the medulla is four inches in diameter. The cerebrum has a large amount of gray neurine in the convolutions; and the animal is known to be one of the most sagacious of quadrupeds. Its memory of friends and foes extends a life time.

The muscles of the elephant are distributed to the limbs from the vertebral column, scapulæ, and pelvic bones, much as they are in the larger and more familiar quadrupeds. The most striking feature of them is their massiveness. In the mechanism of the elephant there is provision for the outlay of physical force, and no adaptation for speed or agility. The ordinary walk of the elephant is a little faster than a corresponding gait in the horse. When hastened by fright the animal manages to escape with an ambling stride, which a horse has to gallop to match in speed. The leg joints are poised perpendicularly, one over the other, so that it is difficult to determine whether the backward or forward swing of a joint is to be called flexion.

The tendons of the muscles of the legs which extend to the feet are white and glistening cords, an inch in diameter; they are stronger than any cordage of equal size, and they move in sheaths with less friction than can be attained in the best machinery.

The sole of the elephant's foot is an immense cushion of yellow elastic tissue, too dense to be punctured by stubs or sharp stones. The bottom surface is quite flat, yet it shows the outline of the digital hoofs. Although the elephant takes quite long steps, and in an ungainly manner, the creature has such finely padded toes that it's foot-fall cannot be heard but a short distance. The track of the beast in mud or sand leaves no digital marks. In walking, a fore and hind limb on one side of the body move at a time, and the hind foot is placed almost in the spot indented by the fore foot. This peculiar gait gives a swinging or swaying motion to the body as each step is taken, making it quite difficult for a person to keep his seat while riding on the animal's back.

The skeleton of the elephant presents some interesting peculiarities, one of which is the giant air-cells of the cranium, the sinuses extending into the diploic spaces, pressing the tables of the skull twelve inches apart in some places. No other animal exhibits such a chambered cranium. The nasal passages, high on the forehead, quite resemble the "blow-holes" of the whale.

So far as cervical vertebræ are concerned the elephant adheres to the mammalian type by having seven individual pieces. The spinous process of the seventh rises high, conforming in this respect to the spines of the first dorsal bones. To these spines is attached the huge ligamentum nuchæ that sustains the head weighed down with tusks. The elephant has twenty-three dorsal or trunk vertebræ, and nineteen or twenty of these sustain ribs. The shoulder-blades exhibit a branch process from the spinous ridge on the dorsum of the scapula. It extends backward two or three inches at a right angle from the regular spinous process. The glenoid cavity is shallow, and twice as long as broad. It looks downward, therefore the scapula rises vertically above the humerus. The top of the blade reaches higher than the tip of the spine of the seventh cervical vertebra. The humerus bears the ordinary characteristic of the typical bone. The great tuberosity rises higher than the articular face of the bone. The deltoid ridge extends below the middle of the humerus, and the bicipital groove is deep. The radius and ulna cross each other obliquely on their way from the condyles of the humerus to the carpus, the radius keeping in front. The ulna is the larger bone of the two. The carpal bones number eight, and are placed in two rows, one above the other. They articulate with each other, and with adjacent bones above and below, by means of flat surfaces. Of the phalanges, there are two in the first, and three in the other four digits. Each ungual phalanx is incased in a hoof; and all, as before indicated, terminate in a thick sole.

The pelvic girdle slopes downward so rapidly from the normal axis of the vertebral column, that the out-spreading ilia look upward as in the human pelvis. The sacrum consists of four blended vertebræ, and the caudal appendage has thirty-three distinct bones. The pubic and ischeal bones are comparatively small, the expanded ilia having been extended at their expense. The obturator foramen is smaller than the acetabulum. The head of the femur is globular and free from a ligamentum teres. The trochanter major does not rise so high as the head of the bone, and the lesser trochanter is comparatively small. The bone is shaped so much like the human femur that sharpers have exhibited it as that of a giant. The tibia and fibula compare so well with those in the human leg that they might pass upon the unwary as relics of a giant fifteen feet high. The seven

tarsal bones in the elephant's foot bear a close resemblance to corresponding bones in a man, but the inner digit which represents the hallux is a dwarfed affair, especially in the African species.

The elephant lies down and rises up with comparative ease, but in a very clumsy manner. The creature in settling down allows the hind legs to extend backwards till one hip is near the ground, and then drops unguardedly upon the protuberant abdomen and side. The huge animal in this terminal movement of lying down falls so helplessly that it would seem a hopeless task to rise again. But the somewhat flexible or mobile joints help the prostrate creature to raise the hips with ease, and to poise the ponderous trunk upon the legs.

The enormous weight of a full-grown elephant, and the awkward use of its limbs, would seem to warn the animal not to venture in miry places, but facts are against the supposition. The elephantidæ delight to wallow in the mud and mire of swampy places, and to sport in ponds and streams. I never knew a tame elephant to become inextricably stranded in a quagmire of its own choosing as a wallowing place.

In reviewing the peculiarities of the elephant, I forgot to mention in the proper place that in the skin on the side of the head, between the eye and the ear, there exists a small opening, which is the commencement of a duct an inch or two in length, running towards the lachrymal organs (if it do not reach a gland in the orbital cavity), that leads to a secretory apparatus. A gummy substance is produced in the canal, which sometimes clogs the external opening. This lachrymal appendage is prominent in the cervidæ, and when the duct becomes obstructed in the deer, the animal employs the point of one of its hind hoofs to clear away an obstacle to free discharge. The elephant, to accomplish a similar purpose, selects a straw or dry twig, with its proboscidian digit, and probes the canal as skillfully as a surgeon. The keeper of Mr. Robinson's herd of elephants took me among the creatures in order to show one of the animals that was actually attempting to permeate the sinus with a piece of dead twig selected from a bundle of hay. The elephant stood still and patiently waited for the keeper to use a smooth stick, kept for that purpose, in clearing the obstructed passage. The probing seemed to be enjoyed by the appreciative beast.

The Asiatic or Indian elephant is more docile and tractable than the African, and, in a captive state, is employed as a beast of burden. Having been shown where to drag timber, the faithful creatures will work all day just as shown in the morning, two or three together using their trunks, tusks, and even shoulders in the process of piling up lumber, bales, boxes, and barrels. Besides being found in India, the Asiatic elephant is met in Burmah, Siam, Ceylon, Sumatra, and Borneo. The ears of the Indian elephant are small when compared with those of the African species. The forehead of the Asiatic elephant is flat and even indented, while that of the African is convex and bulging.

An albino or white elephant, a rare creature, has superstitiously ascribed to it certain protective powers which extend to its owners. The primitive Indian princes used to wage long and bloody wars for the possession of one of these strangely marked beasts.

An interesting peculiarity of elephantidæ is that more species are extinct than now living. This has led to the speculation that the two species, Asiatic and African, now on earth, are late lingerers of a race on its way to extinction. The theory is presented that a cold period in the earth's history killed off all of the elephant family except such as were accidentally protected in tropical latitudes. And the theory obtains some support from the fact that carcasses of mammoths have been found preserved in the ices of Siberia. An ivory hunter by the name of Schumachoff, while looking along the shores of Lake Oncoul for mammoth tusks in 1803, came across the carcass of an *Elephas primigenius* which was being gnawed by dogs, wolves, and bears, so fresh and well kept was the flesh. The remains were afterwards taken to St. Petersburg, and mounted. The skin was thickly covered with a dense wool, through which projected long black hairs or bristles. This protective covering shows conclusively that the animal was accustomed to a very cold climate, and does away with the theory that a tropical climate once extended to the neighborhood of the polar regions; and that a change of temperature occurred so suddenly that the elephants then abounding in high latitudes were instantly overwhelmed with cold, and became incased in perpetual ice. It is possible that Siberia is now too cold for the mammoth, yet as far north as its remains are found there are pines, willows, and birches upon which the creature might feed; and its thick and complex coat of wool and hair would enable the animal to live in as high latitudes as the musk ox thrives in British America.

The mastodon was nearly as large as the mammoth, and they were contemporaries, though the former stuck pretty closely to temperate climates. Nipple shaped cusps on the grinders gave the creature the name of mastodon. The tusks of the animal sometimes measured fourteen feet from tip to base; and they curved more gently than they did in the mammoth. The cabinet of the Cincinnati Society of Natural History contains some fine specimens of mammoth and mastodon tusks that were excavated from alluvial soil near Big Bone Springs, in Kentucky. Similar relics have been discovered in all parts of the West and South, and nearly complete skeletons have been exhumed in New Jersey and New York. Kindred osseous remains of the larger proboscidians are found in the various latitudes of Europe, showing that animals decidedly elephantine in character were once well distributed through the northern temperate zone; and observations made in latitudes of the equator demonstrate a general distribution of the elephantidæ over all parts of the habitable earth.

Remnants of proboscidians in a fossil or petrous state have been discovered in Miocene deposits, yet the larger of the elephant family did not appear till late in the Tertiary epoch of geological history. What is called the Glacial or Drift period was probably quite fatal to huge pachyderms, yet representatives of various species reached the modern river system, for their bones are found in gravel beds, and the alluvium of bottom lands. In some instances teeth and bones are associated with those of modern deer and bison; but there exists no positive evidence that the earliest inhabitants of the American continent ever beheld a living mammoth or mastodon.

THE LAST CALL. BY C. B. BIRCH. IN THE EXHIBITION OF THE ROYAL ACADEMY.

## THE LAST CALL.

MR. BIRCH'S group at the Royal Academy represents a hussar struck mortally wounded, both man and horse, at the moment of charging, and as the man has just sounded the charge. The horse drops nerveless, head downwards, breaking its neck. The man will, of course, in the next moment be thrown forward also; but, with a fine discrimination in the attitude, the sculptor suggests that in the death spasm the soldier erects himself for an instant in the saddle, throwing the arm with which he holds his clarion high above his head, as he would very likely do if struck in the heart. It is well known that a wound in the heart will often occasion a sudden and prodigious muscular effort, causing a man sometimes, when struck on foot, to leap in the air. There is a little technical point in this sculptural representation to which cavalry men may take exception. The cavalry trumpeter is, we believe, provided with both a trumpet and a small bugle; the former being usually slung behind his back, when, with the latter, the charge is sounded. But we may readily suppose that the bugle has been lost in the excitement of battle, perhaps even shot away, and the sculptor has not exceeded an artist's license in placing the more sightly, important, and, so to say, poetic instrument, in his hero's hand. The difficult attitude of the falling horse is perfectly mastered, and not less so the well-conceived and spirited action of the man.

The modeling of both figures is unexceptionably good. If such a work as this were produced in France and Germany it would make a sculptor's reputation, and the Government would immediately commission the execution of the work, and probably replicas of it, in an enduring material. In the absence of state patronage in this country, cannot one of our great military clubs commission this work, which would form so fitting a decoration for one of their halls?—*Illustrated London News.*

## THE OWL-CRITIC.

"WHO stuffed that white owl?" No one spoke in the shop;
The barber was busy, and he couldn't stop;
The customers, waiting their turns, were all reading
The *Daily*, the *Herald*, the *Post*, little heeding
The young man who blurted out such a blunt question;
Not one raised a head or even made a suggestion,
And the barber kept on shaving.

"Don't you see, Mr. Brown,"
Cried the youth with a frown,
"How wrong the whole thing is,
How preposterous each wing is,
How flattened the head is, how jammed down the neck is—
In short, the whole owl, what an ignorant wreck 'tis?
I make no apology;
I've learned owl-ology.
I've passed days and nights in a hundred collections
And cannot be blinded to any deflections
Arising from unskillful fingers that fail
To stuff a bird right from his beak to his tail.
Mister Brown! Mister Brown!
Do take that bird down,
Or you'll soon be the laughing-stock all over town!"
And the barber kept on shaving.

"I've *studied* owls,
And other night fowls,
And I tell you
What I know to be true:
An owl cannot roost
With his limbs so unloosed;
No owl in this world
Ever had his claws curled,
Ever had his legs slanted,
Ever had his bill canted,
Ever had his neck screwed
Into that attitude.
He can't *do* it, because
'Tis against all bird laws.
Anatomy teaches,
Ornithology preaches,
An owl has a toe
That *can't* turn out so!
I've made the white owl my study for years,
And to see such a job almost moves me to tears!
Mister Brown, I'm amazed
You should be so gone crazed
As to put up a bird
In that posture absurd!
To *look* at that owl really brings on a dizziness;
The man who stuffed him don't half know his business!"
And the barber kept on shaving.

"Examine those eyes.
I'm filled with surprise
Taxidermists should pass
Off on you such poor glass,
So unnatural they seem
They'd make Audubon scream,
And John Burroughs laugh,
To encounter such chaff.
Do take that bird down;
Have him stuffed again, Brown!"
And the barber kept on shaving.

"With some sawdust and bark
I could stuff in the dark
An owl better than that.
I could make an old hat
Look more like an owl
Than that horrid fowl,
Stuck up there so stiff like a side of coarse leather.
In fact, about *him* there's not one natural feather."

Just, then, with a wink and a sly normal lurch,
The owl, very gravely, got down from his perch,
Walked around, and regarded his fault-finding critic
(Who thought he was stuffed) with a glance analytic,
And then fairly hooted, as if he should say:
"Your learning's at fault this time, anyway;
Don't waste it again on a live bird, I pray.
I'm an owl; you're another. Sir Critic, good-day!"
And the barber kept on shaving.

—*James T. Fields, in July Harpers'.*